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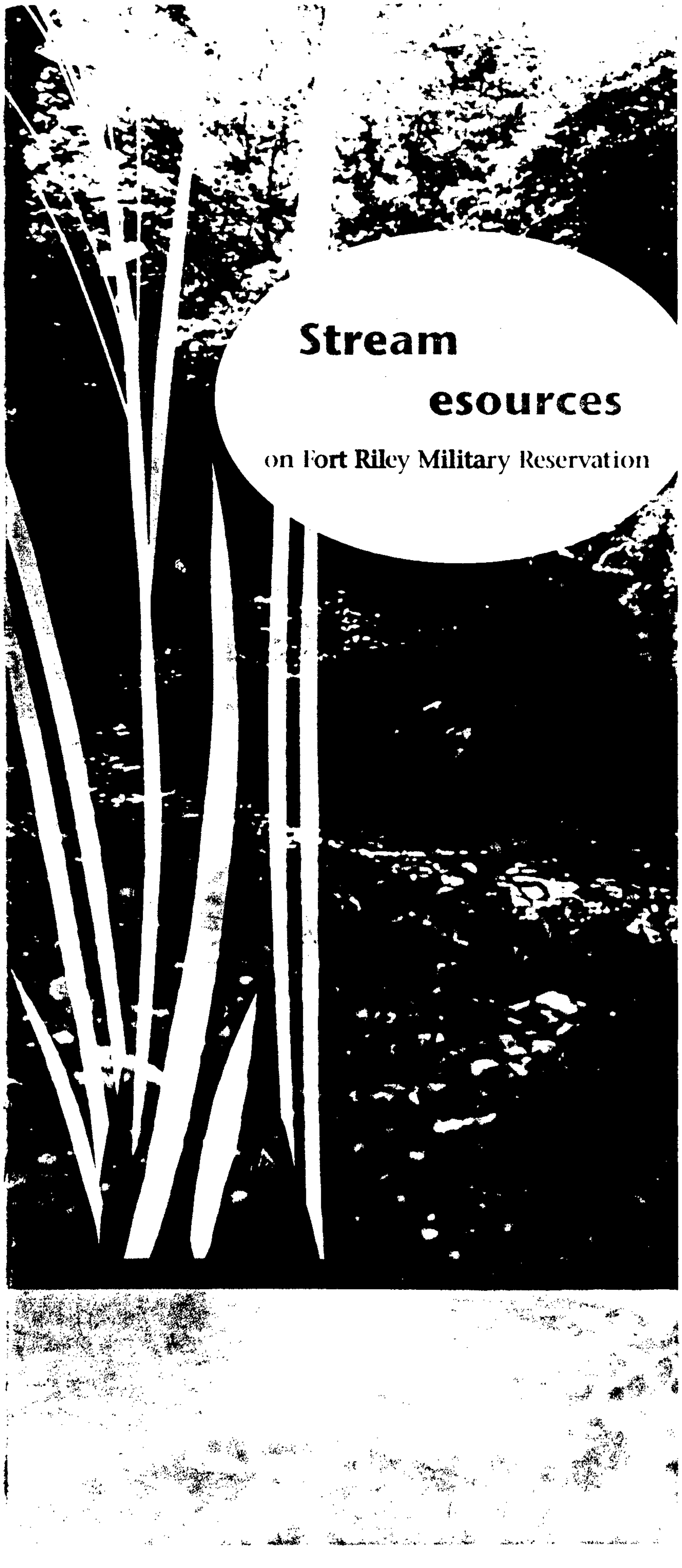


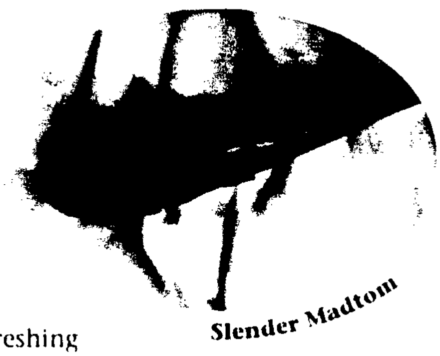
Stream

esources

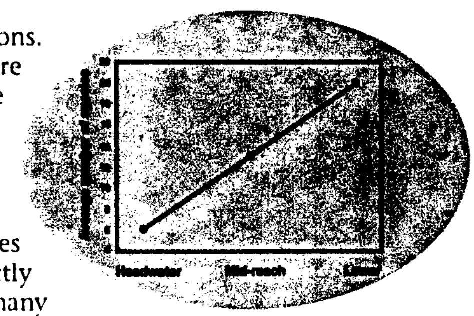
on Fort Riley Military Reservation

Stream Resources at Fort Riley

The Fort Riley Military Reservation is located in the Flint Hills of northeastern Kansas between Junction City and Manhattan. Of the 100,000 acres encompassed by Fort Riley, nearly 70,000 acres are managed for multiple-use, including fish and wildlife management.



In addition to upland bird, waterfowl, and big game hunting, Fort Riley provides excellent angling opportunities. Although many anglers concentrate their effort on ponds, streams provide a refreshing alternative by supplying fishing opportunities with uncrowded conditions. However, streams are important for more than providing a place to fish. Stream and riparian, or streamside vegetation, resources are used both directly and indirectly by many people and various wildlife species.



Healthy streams are the result of proper land management. Proper stream and watershed management ensures high-quality habitat for fish and wildlife.

Streams located on Fort Riley are characteristic of many Flint Hills streams. For example, streams vary from high-gradient and clear water to low-gradient and muddy water and vary in size from small streams with infrequent flow to large permanent-flowing streams.

More than a dozen different streams are located on Fort Riley, many of which are completely contained within the boundaries of Fort Riley and offer a unique opportunity to observe how streams function. In addition, the diversity of streams supports a diverse aquatic community on Fort Riley.

Stream Regions

Headwaters

Most streams on Fort Riley originate from groundwater springs high in the drainage basin. The beginning of a stream, or headwater, is characterized by high gradient, rocky bottom, shallow depth, and narrow width. The water flows relatively fast, helping to maintain a cool temperature and high oxygen concentration, which are important for fish and other aquatic organisms.

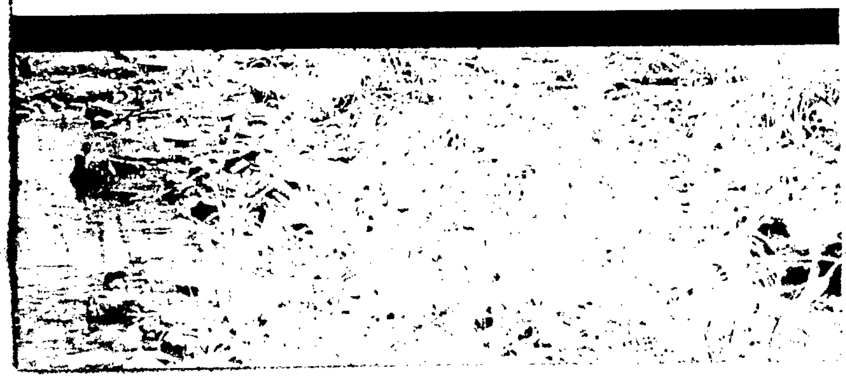
Orangethroat Darter

The orangethroat darter and slender madtom are common fishes in the headwaters of Fort Riley streams and can be found in Little Arkansas, Wind, Threemile, and Forsyth Creeks.

Fishes that live in headwaters are adapted to life in fast-flowing water and are often found under or around cover. Consequently, species located in headwater streams are small and flat to increase survival in the fast, turbulent flow. Most fish in these areas feed on aquatic insects that live in the spaces between rocks.

Headwaters usually have the fewest number of species, and the number of fish species increases downstream.

Forsyth Creek

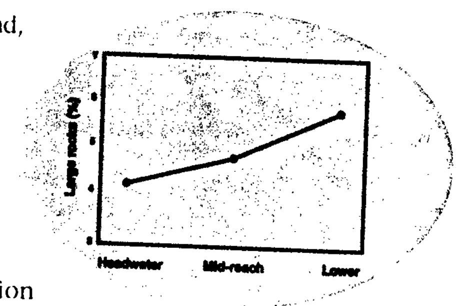


Mid-reaches

As a stream progresses, it receives input from other streams and grows in size. The middle section of a stream is called a mid-reach. Gradients in mid-reach areas are lower than in headwater reaches, allowing fine particles like silt to settle out. Unlike headwater reaches composed primarily of riffles, mid-reaches have well developed pool-riffle sequences.

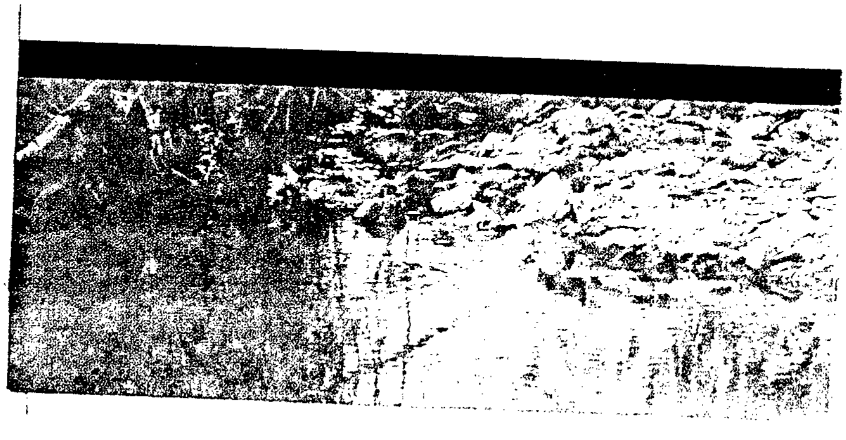
Creek Chub

Most of these areas also have well-developed riparian forests that increase instream habitat. For example, when trees fall into the stream they provide cover and spawning cavities and increase area for aquatic insect production.



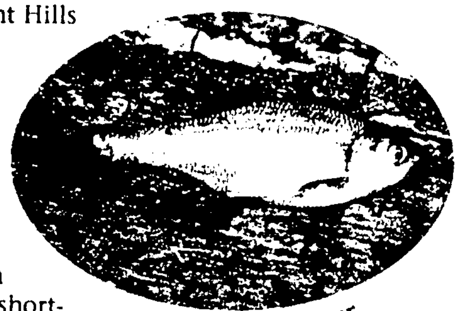
Little Arkansas, Wind, and Forsyth Creeks have good examples of mid-reach sections on Fort Riley. Fish communities in mid-reaches typically contain several different species because of the variation in habitat and increased water volume. Fish species found in riffles are similar to those found in headwaters, but many new species such as red shiners, redfin shiners, common shiners, black bullheads, and bluntnose minnows are common in these areas because of the abundant food supply and diverse habitat. Predatory fish such as green sunfish and creek chubs are more common in mid-reaches than in the headwaters due to the abundance of prey species.

Wind Creek



Lower reaches

Gradients decrease downstream, and the stream becomes wider and deeper. It may look like there is little cover for fish, but below the surface, logs and large rocks provide habitat for numerous fish species. Threemile, Sevenmile, Wildcat, and Madison Creeks on Fort Riley are excellent examples of lower stream reaches characteristic of Flint Hills streams.



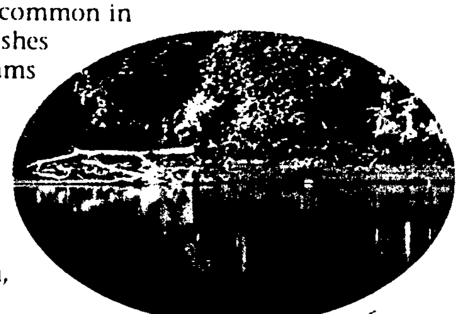
Red Shiner

Lower reaches have many fish species. For example, finding 20 or more fish species in a lower reach is common. Bluegill, largemouth bass, white suckers, shorthead redhorse, logperch, and suckermouth minnows are common fishes in lower reaches. Because these streams flow into large rivers or reservoirs, many large-river and reservoir fish species such as river carpsucker and walleye have been collected in streams on Fort Riley.

Large rivers

All streams on Fort Riley eventually flow into either the Kansas or Republican Rivers, which border the southern boundary of Fort Riley. Both rivers are typical midwestern rivers characterized by broad channels with shifting-sand bottoms.

Fishes such as smallmouth buffalo, blue sucker, and flathead catfish are common in large rivers. Many fishes that live in the streams on Fort Riley, like red shiners and channel catfish, also inhabit large rivers; however, several species, such as shovelnose sturgeon, are adapted for life in large-river habitats and do not exist in smaller streams.

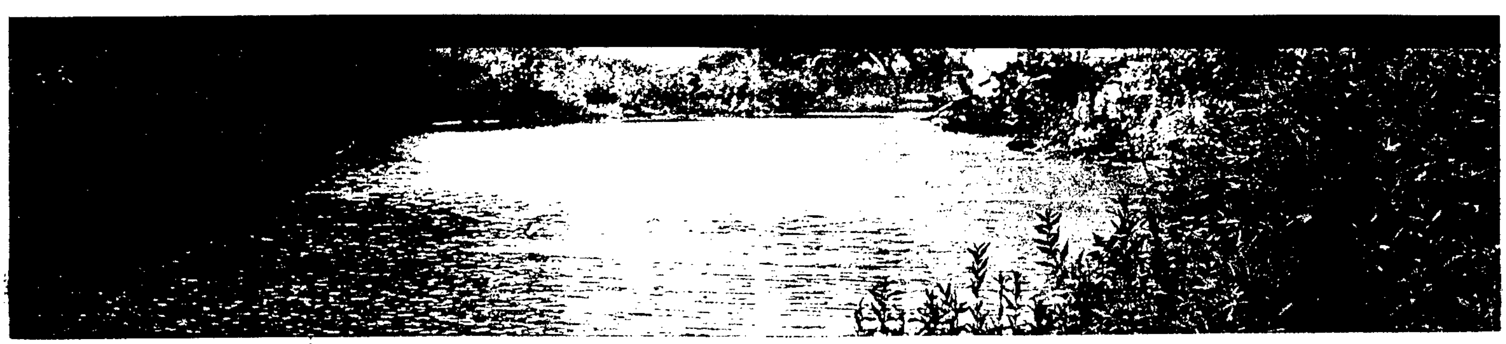


Kansas River

Comprehensive list of fishes that occur in Ft. Riley's streams and rivers

Common Name	Scientific Name	Primary Habitat: Headwater	Mid-Reach	Lower Reach	Large River
Sturgeons (Acipenseridae)					
Shovelnose sturgeon	*Scaphirhynchus platorynchus*				X
Gars (Lepisosteidae)					
Longnose gar	*Lepisosteus osseus*			X	X
Shortnose gar	*Lepisosteus platostomus*			X	X
Mooneyes (Hiodontidae)					
Goldeye	*Hiodon alosoides*				X
Herrings (Clupeidae)					
Gizzard shad	*Dorosoma cepedianum*				X
Minnows (Cyprinidae)					
Central stoneroller	*Campostoma anomalum*	X	X	X	X
Red shiner	*Cyprinella lutrensis*	X	X	X	X
Common carp	*Cyprinus carpio*			X	X
Plains minnow[a]	*Hybognathus placitus*				X
Common shiner	*Luxilus cornutus*	X	X	X	
Speckled chub[b]	*Extrarius aestivalis*				X
Redfin shiner	*Lythrurus umbratilis*	X	X	X	
Golden shiner	*Notemigonus crysoleucas*				X
Emerald shiner	*Notropis atherinoides*				X
Sand shiner	*Notropis ludibundus*			X	X
Rosyface shiner	*Notropis rubellus*			X	X
Topeka shiner[c]	*Notropis topeka*	X	X	X	
Suckermouth minnow	*Phenacobius mirabilis*	X	X	X	
Southern redbelly dace	*Phoxinus erythrogaster*	X	X	X	
Bluntnose minnow	*Pimephales notatus*	X	X	X	
Fathead minnow	*Pimephales promelas*	X	X	X	X
Bullhead minnow	*Pimephales vigilax*	X	X	X	
Creek chub	*Semotilus atromaculatus*	X	X		
Suckers (Catostomidae)					
River carpsucker	*Carpiodes carpio*				X
Quillback	*Carpiodes cyprinus*				X
White sucker	*Catostomus commersonii*		X	X	X
Blue sucker[a]	*Cycleptus elongatus*				X
Smallmouth buffalo	*Ictiobus bubalus*				X
Bigmouth buffalo	*Ictiobus cyprinellus*				X
Shorthead redhorse	*Moxostoma macrolepidotum*		X	X	
Catfishes (Ictaluridae)					
Black bullhead	*Ameiurus melas*		X	X	X
Yellow bullhead	*Ameiurus natalis*		X	X	X
Channel catfish	*Ictalurus punctatus*		X	X	X
Slender madtom	*Noturus exilis*		X	X	X
Stonecat	*Noturus flavus*		X	X	X
Flathead catfish	*Pylodictis olivaris*			X	X
Killifishes (Fundulidae)					
Blackstripe topminnow	*Fundulus notatus*				X
Livebearers (Poeciliidae)					
Mosquitofish	*Gambusia affinis*				X
Temperate Basses (Percichthyidae)					
White bass	*Morone chrysops*				X
Sunfishes (Centrarchidae)					
Green sunfish	*Lepomis cyanellus*		X	X	X
Orangespotted sunfish	*Lepomis humilis*		X	X	X
Bluegill	*Lepomis macrochirus*		X	X	X
Longear sunfish	*Lepomis megalotis*			X	X
Spotted bass	*Micropterus punctulatus*		X	X	
Largemouth bass	*Micropterus salmoides*		X	X	X
White crappie	*Pomoxis annularis*		X	X	
Perches (Percidae)					
Johnny darter	*Etheostoma nigrum*	X	X	X	X
Orangethroat darter	*Etheostoma spectabile*		X	X	X
Logperch	*Percina caprodes*		X	X	X
Walleye	*Stizostedion vitreum*		X	X	
Drums (Sciaenidae)					
Freshwater drum	*Aplodinotus grunniens*				X

[a] Species In Need of Conservation (SINC) [b]State Endangered Species [c]Federal Endangered Species



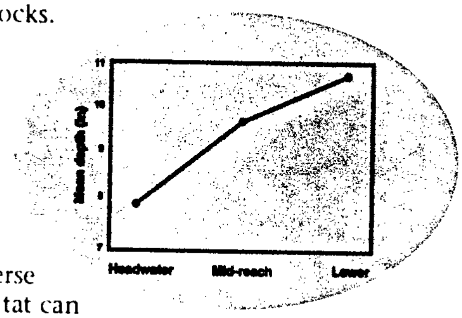
Importance of Maintaining Quality Habitat

Physical habitat is the most important aspect for fish and other aquatic organisms in streams. Structures such as stumps, logs, boulders, and streamside vegetation are all examples of habitat.

Habitat is a broad term that has different meanings to different species. For example, an individual fish may feed on insects in rocky riffles, hide from predators in aquatic vegetation, and spawn under a log. On the other hand, a different fish may spend its entire life near rocks.

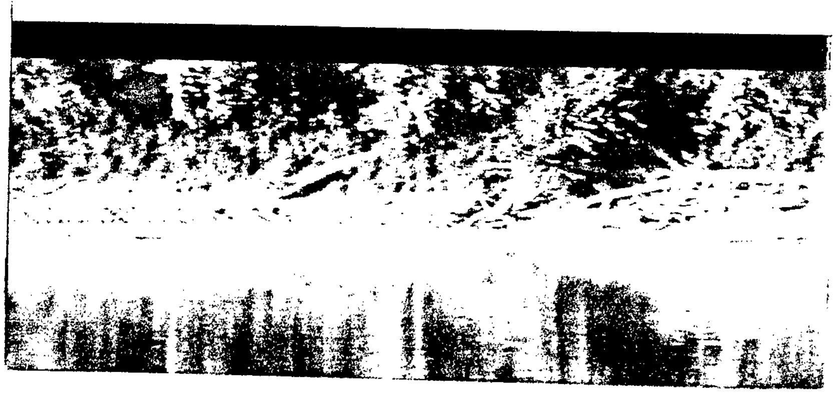

Longear Sunfish

In general, streams on Fort Riley have excellent habitat for fishes. Little Arkansas, Forsyth, and Sevenmile Creeks are examples of streams with diverse habitat. Loss of habitat can result from land-use practices and may influence individual species and disturb community interactions.



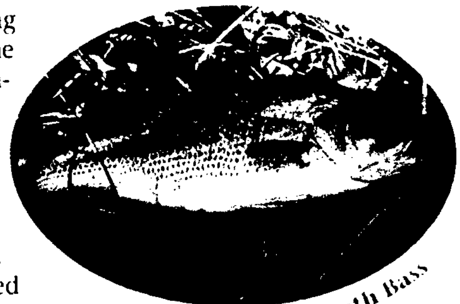
Land-use practices can influence habitat in many ways. The most common is increased erosion in the watershed and subsequent sedimentation.


Forsyth Creek



Which Fishes Can Be Found on Fort Riley?

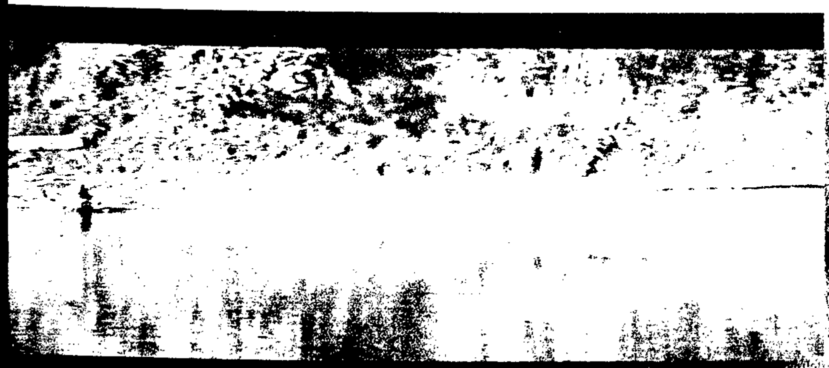
More than 50 different fish species can be found in the streams and rivers on Fort Riley. Several game species are abundant, including bluegills, largemouth bass, spotted bass, and channel catfish.



Largemouth Bass

Dozens of interesting and unique nongame species are also common on Fort Riley. Many of the nongame species, such as the southern redbelly dace and longear sunfish, are brilliantly colored and have unique adaptations to life in flowing water. The Topeka shiner (an endangered species) is present in several streams along the western boundary of Fort Riley.

Despite a decline in abundance across its distribution, several streams in the Flint Hills appear to have healthy Topeka shiner populations. Similarly, the plains minnow (an uncommon species) has been collected in the Kansas River on Fort Riley. In addition to the various fishes, many other organisms—such as freshwater mussels, crayfish, reptiles, amphibians, and insects—call streams home.



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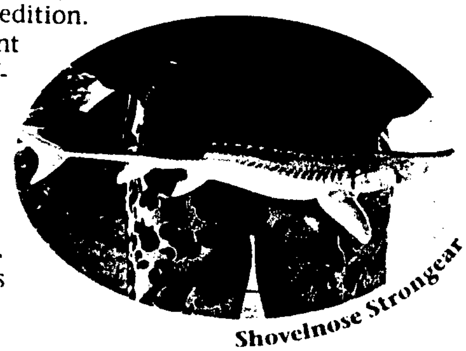
Tomelleri, J. R., and M. E. Eberle. 1990. *Fishes of the central United States.* University of Kansas Press, Lawrence.



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Fort Riley, KS 66442-6016

STRUCTURE AND FUNCTION OF FISH COMMUNITIES IN STREAMS ON FORT RILEY MILITARY RESERVATION

by

Michael Carl Quist

B.S., University of Idaho, 1996

A THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

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College of Arts and Sciences

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Major Professor
Christopher S. Guy

ABSTRACT

Instream habitat is important in determining fish community characteristics; however, few studies have been conducted to assess the influence of physicochemical habitat on fish community structure and function in tallgrass-prairie streams. In addition, the effects of large-scale disturbance on soil characteristics and plant communities are well documented, but little is known about the influence of military activities on soil and vegetation and the effects on instream habitat and fish community characteristics in small, lotic ecosystems. The purpose of this study was to provide baseline information on the relationships among physicochemical habitat and fish community structure and function on Fort Riley Military Reservation and to assess the influence of large-scale disturbance from military activities on instream habitat and fish assemblages. Sampling sites were selected from headwater, middle (mid), and lower reaches based on drainage area. Physical habitat and fish communities were sampled within each macrohabitat (i.e., pools and riffles). Analysis of variance was used to determine differences in habitat and fish community characteristics among reaches and relationships among abiotic and biotic variables were analyzed using correlation and regression techniques.

Water chemistry variables (e.g., dissolved oxygen, reactive phosphorous) were similar among reaches; whereas, physical habitat (e.g., depth, width) increased longitudinally. Percent disturbance within the watershed and percent silt were highest in headwater reaches. In general, large substrate (e.g., cobble, pebble) was most abundant in mid and lower reaches. Aquatic vegetation and woody debris were the most common forms of cover in all reaches and macrohabitats.

Percent disturbance within a watershed was positively correlated with percent silt

in pool macrohabitats from headwater and mid reaches. Percent canopy cover was negatively correlated with aquatic vegetation in all reaches and positively correlated with area of woody habitat (e.g., bank root, rootwad) in headwater and mid reaches. In addition, woody-riparian vegetation was negatively correlated with mean daily, maximum daily, and maximum daily range in temperature in mid reaches. In riffle macrohabitats, percent disturbance was negatively correlated with mean depth, width, and velocity for headwater reaches.

Percent disturbance from military activity was associated with high catch per unit effort (C/f) of tolerant species and trophic generalists. Despite high percent silt in headwater reaches, percent disturbance and percent silt were rarely correlated with fish community characteristics. Headwater sites that were dominated by silt substrate generally had few species; whereas, a minimal increase in habitat heterogeneity (i.e., increased percent gravel) was associated with higher species richness. The increase in species richness was due to the addition of trophic generalists and tolerant species. Species richness and diversity were positively correlated with percent disturbance in mid-reach watersheds and was reflective of increased abundance of omnivores and tolerant species. In riffle macrohabitats, percent disturbance was negatively correlated with C/f of benthic-insectivores in headwater reaches and positively correlated with C/f of tolerant species in mid reaches.

Riparian area variables (e.g., canopy cover, bank root) in pool macrohabitats were positively correlated with trophic guild diversity, C/f of benthic-insectivores, generalized-insectivores, omnivores, and intolerant species among reaches. Similar relationships were found in riffle macrohabitats where riparian area variables were

positively correlated with C/f of benthic-insectivores and omnivores and negatively correlated with C/f of tolerant species. In addition, mean back-calculated lengths at age for central stonerollers *Campostoma anomalum*, creek chubs *Semotilus atromaculatus*, red shiners *Cyprinella lutrensis*, and green sunfish *Lepomis cyanellus* were positively correlated with area of woody habitat. The proportion of age-0 central stonerollers and creek chubs was positively correlated with habitat characteristics associated with poor-quality habitat (e.g., low percent canopy cover, shallow depth, small substrate). Few biotic interactions were found in headwater and lower reaches; however, growth of central stonerollers, creek chubs, red shiners, and green sunfish was negatively correlated with their abundance– suggesting that density-dependent factors influenced growth.

These results indicate that habitat and fish communities in streams from the Flint Hills exhibit similar longitudinal patterns as other ecosystems. They also suggest the importance of large-scale disturbance and woody-riparian vegetation to instream habitat and fish community structure and function. In addition, riparian areas provide an important link between land-use and instream process. However, riparian areas apparently failed to filter surface runoff and decrease sedimentation in streams on Fort Riley. This is likely due to the presence of numerous stream crossings which disrupt riparian continuity and provide access of silt to streams.

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I thank my major advisor, Dr. Christopher Guy, for his patience, suggestions, guidance, and friendship. I am also thankful for the many helpful comments from Dr. Harold Klaassen and Dr. Jeffrey Pontius. A special thanks to Joel Delp, Tara Elbel, Tom Hungerford, and Greg Norris for their tireless effort in the field. I also thank Phil Fay, Kyle Hedges, Dave Jones, Chris Mammoliti, Mark Shaw, and Craig Phillips for their assistance. Thanks to Pat Braaten, Matt Burlingame, Travis Horton, Brett Rubenstein, Jeff Tillma, Jeff Tripe, and the numerous other students in the Division of Biology who were always open to new ideas and willing to provide answers to my continual questions.

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Introduction

Fish community characteristics often reflect the quality of physicochemical habitat in stream ecosystems. Physical and chemical habitat influence fish community structure (e.g., species composition; Gorman and Karr 1978) and function (e.g., growth; Putnam et al. 1995). Thus, understanding and recognizing the influence of habitat on fish communities is important for fisheries scientists to properly manage aquatic resources (Funk and Pflieger 1975; Larimore 1981; Winger 1981).

Numerous researchers have documented the influence of instream habitat on fishes using correlation and regression techniques. These techniques have been a useful management tool for predicting fish abundance and distribution from instream habitat (Fajen 1981; Orth and Maughan 1982; Helm 1984; McClendon and Rabeni 1987; Fausch et al. 1988). For example, Binns and Eiserman (1979) found that trout *Salvelinus* spp., *Salmo* sp., and *Oncorhynchus* spp. standing stock in Wyoming streams was related to physicochemical habitat such as instream cover, substrate type, current velocity, and nitrate concentration. Scarnecchia and Bergersen (1987) found that production and biomass of trout *Salvelinus* spp. and *Salmo* sp. were negatively correlated with elevation and positively correlated with substrate diversity, conductivity, alkalinity, and water hardness. McClendon and Rabeni (1987) documented that density and biomass of smallmouth bass *Micropterus dolomieu* and rock bass *Ambloplites rupestris* were best explained by the amount of boulder, cobble, undercut bank, and aquatic vegetation in a Missouri stream. In Kansas and Oklahoma streams, Layher and Maughan (1985) compared standing stock of channel catfish *Ictalurus punctatus* to nineteen habitat

variables and found that runoff, percent of stream area as runs, and water temperature explained nearly 50% of the variability in channel catfish biomass. Tillma et al. (in press) documented that the area of rootwad and undercut bank explained 62% of the variation in spotted bass *Micropterus punctulatus* biomass in southeast Kansas streams. Although some research has been conducted on habitat-species relationships in Kansas, no studies have documented the effects of disturbance within watersheds on streams in tallgrass-prairie ecosystems.

Physicochemical habitat can be altered in various ways by large-scale disturbances. Several authors have documented increased erosion and sediment transport to streams from agricultural practices including row-crop agriculture (Costa 1975; Clark 1987) and livestock grazing (Meehan and Platts 1978; Platts 1991). Similarly, timber harvest practices (Furniss et al. 1991), mining (Nelson et al. 1991), and urban development (Wolman and Schick 1967; Simmons 1976) can increase nutrient and sediment inputs to lentic and lotic ecosystems. Sedimentation typically reduces interstitial spaces among rocks and other forms of habitat used by stream fishes (McCrimmon 1954; Cordone and Kelley 1961). Furthermore, sedimentation can decrease aquatic macroinvertebrate production (Lemly 1982), which also influences stream fishes.

Disturbance often reduces habitat heterogeneity in stream ecosystems. Gorman and Karr (1978) determined that natural streams contained more heterogeneous habitat than modified streams and supported more diverse fish communities. Pearsons et al. (1992) suggested that fish assemblages were more diverse in stable, structurally complex

streams compared to streams with homogeneous habitat. In Illinois, Schlosser (1982a) found that trophic structure, age structure, and biomass of fish were more stable in an unmodified stream than a channelized stream. Angermeier and Karr (1984) removed woody debris from one side of a small Illinois stream and found that substrate became homogeneous, depth was reduced, and the amount of organic litter decreased on the cleared side. Consequently, 60% of the fish species were more abundant on the side with woody debris. These studies indicate the importance of habitat to fish communities and the effects of habitat composition on fish community structure and function.

Disturbance from military activity has been shown to deleteriously affect soil properties and plant communities (Wilson 1988); however, the influence of these practices on stream ecosystems is unknown. The Flint Hills region of Kansas contains the only extensive tract of tallgrass prairie in the U. S. (Bragg and Hulbert 1976; Zimmerman 1985; Knapp and Seastedt 1986; Lauver 1994); however, little research has been conducted on streams in this ecosystem. Therefore, the goal of this study was to identify factors influencing physicochemical habitat and fish community characteristics on Fort Riley Military Reservation in a tallgrass-prairie ecosystem. Most of the streams on Fort Riley are completely contained within the boundaries of the installation which provides a unique opportunity to examine physicochemical habitat, fish communities, and disturbance on a large scale. The specific objectives were to 1) describe differences in physical and chemical habitat, 2) describe fish community structure (i.e., age, trophic) and growth of fishes, 3) assess the influence of large-scale military disturbance and riparian vegetation on physicochemical habitat and subsequent effects on fish community

characteristics, and 4) describe fish community interactions in the streams on Fort Riley Military Reservation. I hypothesized that chemical habitat would be similar among sites, but physical habitat (e.g., area of cover) and fish community characteristics (e.g., species richness) would increase longitudinally. I also hypothesized that disturbance from military activity would adversely affect instream habitat and negatively influence species richness, species diversity, and abundance of fishes. In addition, I hypothesized that high-quality riparian areas would moderate the influence of disturbance within the watersheds on habitat and fish communities.

Study Area

The Flint Hills region, which extends from northeast Oklahoma north to northeast Kansas (Figure 1), is characterized by extensive limestone breaks and shallow, rocky soils comprised primarily of chert (Zimmerman 1985). Küchler (1974) classifies the potential natural vegetation as tallgrass prairie dominated by little bluestem *Andropogon scoparius*, big bluestem *A. gerardii*, indiangrass *Sorghastrum nutans*, and switchgrass *Panicum virgatum*. Extensive riparian forests are comprised primarily of oak *Quercus* spp. and hackberry *Celtis occidentalis*. Sharp relief and rocky soils have hindered extensive cultivation; thus, the Flint Hills region contains the largest remnant of tallgrass prairie in North America (Bragg and Hulbert 1976; Zimmerman 1985; Knapp and Seastedt 1986; Lauver 1994). Streams in the Flint Hills have relatively high gradients (Metcalf 1966). Degredation of large quantities of limestone and shale have been transported to the streams and often form the dominant substrate. Streams in the Flint

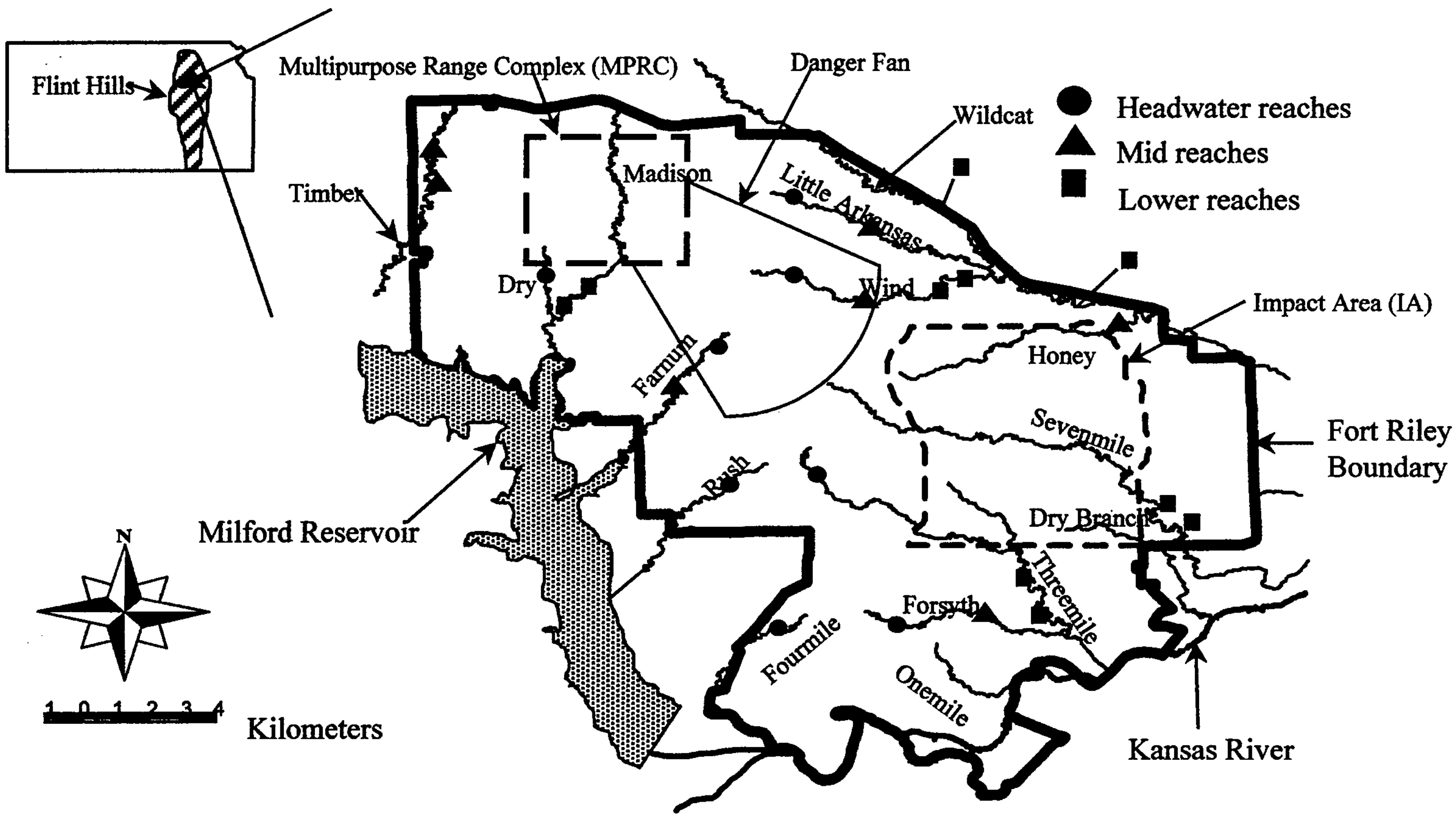

Figure 1. Location of the Flint Hills region of Kansas and stream reaches sampled during June and July 1997, 1998 on Fort Riley Military Reservation.

Hills support the most diverse fish fauna of the Kansas River basin.

Fort Riley Military Reservation is located in the Flint Hills region of northeast Kansas, Riley, Geary, and Clay counties (Figure 1). Fort Riley encompasses approximately 40,200 ha and is the site of military training such as field maneuvers, mortar and artillery fire, and small-arms fire (U. S. Army 1994). In addition, combat-vehicle operations (e.g., M1A1 tanks, M2/M3 and M113 personnel carriers) are common throughout the year. The southern portion of the installation includes most of the developed areas which provide housing and other facilities for Fort Riley's personnel. Training and maneuver areas are generally limited to the northern portion of the installation. A 6,480 ha Impact Area (IA) is off limits to maneuver training, public use, and management related activities at all times (Figure 1), while the Multipurpose Range Complex (MPRC) and adjacent danger fan are closed to public use and management activities during live-fire operations (Figure 1). The remaining areas are open throughout the year except during times of large-scale training activities. The majority of the landscape on Fort Riley is representative of Flint Hills topography; however, the western portion of Fort Riley has less relief and several areas were once cultivated. Currently, agricultural practices are limited to small wildlife food plots, limited haying of prairie grasses, and row-crop leases along the fire-break bordering the installation (C. Phillips, range conservationist, personal communication). Fifteen streams are located on Fort Riley (Figure 1) including portions of the Kansas and Republican rivers which were excluded from this study. Most of the streams are perennial due to groundwater input and few streams contain impoundments within their watershed.

Methods

Streams were delineated into headwater, middle (mid), and lower reaches. Classifications were based on field observations and subsequent analysis of drainage areas according to the following criteria; headwater reaches (0 - 9.0 km^2), mid reaches (9.1 - 20.0 km^2), lower reaches ($\geq$20.1 km^2). Two sites were randomly selected for each reach to represent the abiotic and biotic characteristics of the reach (e.g., two sites within the headwater reach of Wind Creek; Figure 1). Several reaches were not available for sampling because they were located in restricted areas (i.e., MPRC or IA). Samples were collected during June and July in 1997 and 1998. Sites and years were pooled by stream and reach for a total of eight headwater, six mid, and five lower reaches (Table 1).

Sample sites were generally 35 times the mean stream width (MSW; Lyons 1992; Simonson et al. 1994). Logistically, several sites were too wide to sample 35 MSW; therefore, the maximum length of a reach was approximately 300 m–following the stream sampling protocol established by Kansas Department of Wildlife and Parks (Mammoliti 1993). Water chemistry samples were collected from three locations–one from the upper, middle, and lower portion of the sample site. Temperature (°C) and conductivity (μS/cm) were measured with a Hach CO150 conductivity meter (Table 2). Dissolved oxygen (mg/L as O_2; Hach HRDO Method 8166), turbidity (Formazin turbidity units [FTU]; Hach Absorptometric Method 8237), and reactive phosphorous (mg/L as PO_4^{3-}; Hach PhosVer 3 Method 8048) were measured using a Hach DR-EL/2000 portable laboratory kit. Boyd (1977, 1980) found that field kits are adequate for measuring water quality. In addition, one Hobo Temp® temperature logger was placed at each site during

Table 1. Mean drainage area, gradient, chemical habitat, and percent disturbance by reach (H=headwater, M=mid, L=lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Number in parenthesis represents one standard error.

Stream	Reach	Drainage area (km^2)	Gradient (m/km)	Dissolved oxygen (mg/L)	Phosphorous (mg/L)	Conductivity (μS/cm)	Turbidity (FTU)
Dry	H	5.1 (0.1)	6.4	6.9 (0.02)	0.59 (0.003)	651.0 (0.3)	2.0 (0)
Farnum	H	5.6 (0.9)	9.4	7.6 (1.0)	0.36 (0.11)	541.8 (60.5)	20.0 (10.0)
Forsyth	H	5.7 (0.5)	9.8	7.2 (0.3)	5.50 (0)	730.8 (17.1	28.2 (5.5)
Fourmile	H	6.4 (0.03)	7.7	9.7 (2.0)	0.30 (0.03)	591.5 (26.8)	62.5 (21.5)
Little Arkansas	H	7.2 (a)	5.5	6.6 (a)	0.78 (a)	563.0 (a)	15.7 (a)
Rush	H	5.5 (0.6)	5.4	6.7 (0.03)	0.42 (0.03)	653.0 (4.3)	0.5 (0.5)
Threemile	H	3.8 (0.1)	6.3	9.7 (1.2)	0.24 (0.06)	643.2 (23.2)	44.3 (9.3)
Wind	H	7.2 (0.2)	6.4	7.3 (1.3)	0.39 (0.02)	510.7 (56.0)	21.5 (9.8)
Farnum	M	12.3 (0.5)	3.8	6.7 (0.2)	0.46 (0.07)	637.2 (1.8)	25.0 (6.3)
Forsyth	M	10.8 (0.4)	6.7	7.4 (0)	5.50 (0)	715.8 (22.5)	30.5 (7.5)
Honey	M	16.3 (a)	4.2	7.8 (a)	0.25 (a)	636.3 (a)	0.0 (a)
Little Arkansas	M	16.8 (0.7)	2.8	8.3 (0.6)	0.23 (0.005)	577.0 (24.0)	15.7 (8.3)
Timber	M	16.4 (1.9)	2.7	7.9 (0.6)	0.49 (0.03)	698.5 (11.4)	38.8 (9.1)
Wind	M	15.5 (3.3)	3.9	8.1 (1.0)	0.67 (0.11)	537.3 (12.0)	15.2 (2.8)
Madison	L	35.1 (0.8)	1.9	7.9 (0.7)	0.46 (0.07)	556.2 (90.7)	88.9 (37.1)
Sevenmile	L	37.6 (5.3)	2.2	6.8 (0.5)	0.42 (0.07)	542.0 (65.6)	70.6 (26.6)
Threemile	L	41.3 (1.2)	2.3	7.1 (0.8)	0.31 (0.08)	586.7 (25.5)	42.3 (9.4)
Wildcat	L	80.8 (3.2)	2.6	6.7 (0.9)	0.99 (0.1)	487.9 (114.2)	50.8 (4.4)
Wind	L	23.7 (0.3)	3.9	6.6 (0.5)	0.23 (0.009)	518.0 (14.3)	12.2 (4.9)

Table 1. Continued.

Stream	Reach	Temperature (°C)	Mean daily temperature (°C)	Maximum daily temperature (°C)	Maximum daily range in temperature (°C)	Disturbance (%)
Dry	H	19.6 (0.2)	23.7 (0.2)	29.3	12.0	35.5 (8.6)
Farnum	H	20.2 (3.6)	23.1 (0.4)	29.5	13.9	45.1 (2.7)
Forsyth	H	19.9 (2.8)	22.6 (0.3)	27.1	5.0	2.3 (2.3
Fourmile	H	18.1 (1.1)	21.8 (0.3)	26.2	7.2	23.8 (5.6)
Little Arkansas	H	26.8 ([a])	[b]	[b]	[b]	44.5 (17.4)
Rush	H	18.5 (0.5)	17.9 (0.04)	25.2	6.4	63.8 (18.1)
Threemile	H	14.5 (0.4)	[b]	[b]	[b]	44.5 (7.6)
Wind	H	22.6 (0.6)	21.7 (0.2)	24.6	6.1	50.4 (6.5)
Farnum	M	25.2 (0.5)	24.0 (0.3)	28.2	10.4	43.9 (6.0)
Forsyth	M	22.0 (2.2)	22.3 (0.2)	27.1	6.1	11.0 (5.2)
Honey	M	14.6 ([a])	20.2 ([a])	26.1	9.7	0.1 (0.1)
Little Arkansas	M	19.9 (1.6)	15.2 (0.2)	21.0	5.7	13.4 (4.3)
Timber	M	20.3 (1.2)	21.6 (0.3)	25.8	9.2	14.6 (6.7)
Wind	M	24.5 (1.5)	24.1 (0.4)	30.0	16.7	19.2 (3.7)
Madison	L	23.4 (0.8)	21.3 (0.3)	24.9	6.9	34.5 (14.8)
Sevenmile	L	24.2 (1.1)	21.9 (0.2)	27.1	5.5	21.3 (16.1)
Threemile	L	20.9 (1.3)	[b]	[b]	[b]	15.6 (4.8)
Wildcat	L	23.4 (1.8)	23.6 (0.2)	29.0	13.4	16.5 (4.1)
Wind	L	21.2 (0.7)	22.1 (0.02)	28.4	5.4	8.1 (5.6)

[a] Only one sub-sample was available.
[b] Data loggers were not recovered.

Table 2. Description of physicochemical variables collected from streams on Fort Riley Military Reservation during June and July 1997, 1998.

Variable name	Description
Chemical habitat	
TEMP	Mean temperature (°C) recorded at the time of fish and physical habitat collection.
DO	Mean dissolved oxygen (mg/L).
PHOS	Mean reactive phosphorous (mg/l as PO_4^{3-}).
COND	Mean conductivity (μS/cm).
TURBIDITY	Mean turbidity (FTU).
MNDTEMP	Mean daily temperature (°C) between June 1 and August 17, 1997 and 1998.
MAXDTEMP	Maximum mean daily temperature (°C) between June 1 and August 17, 1997 and 1998.
MAXDRANGE	Maximum daily range in temperature (°C) between June 1 and August 17, 1997 and 1998.
Physical habitat	
MNWID	Mean wetted-stream width (m) weighted by area of the associated macrohabitat.
MNDEP	Mean depth (m) weighted by the area of the associated macrohabitat.
MNVEL	Mean water-column velocity (m/s) weighted by the area of the associated macrohabitat.
Substrate	
BE	Mean percent (%) of bedrock substrate.
BO	Mean percent (%) of boulder substrate.
CL	Mean percent (%) of clay substrate.
CO	Mean percent (%) of cobble substrate.
GR	Mean percent (%) of gravel substrate.
PE	Mean percent (%) of pebble substrate.
SI	Mean percent (%) of silt substrate.

Table 2. Continued.

Cover	
AV	Mean m^2/ha of free-floating, submergent, and emergent aquatic vegetation.
UC	Mean m^2/ha of undercut bank habitat.
BC	Mean m^2/ha of branch complex habitat, defined as overhanging branch and leaf complexes.
BR	Mean m^2/ha of bank root habitat, defined as small roots penetrating stream banks.
LOG	Mean m^2/ha of log habitat, defined as singular logs.
LC	Mean m^2/ha of log complex habitat, defined as a complex assortment of log and other large woody debris.
RW	Mean m^2/ha of rootwad habitat defined as a complex assortment of large roots generally associated with large, woody riparian vegetation.
TWD	Mean m^2/ha of total woody debris (i.e, BC, BR, LOG, LC, RW).
Riparian zone	
CANOPY	Mean canopy cover (%) weighted by the area of the associated macrohabitat.
Disturbance	
DISINDEX	Mean disturbance scores (%) from U. S. Army Land Condition Trend Analysis (LCTA) transects. Scores represent the severity of soil and vegetation disturbance from combat vehicles (e.g., tanks) and is the average percent of sample points where physical disturbances occurred during all years of LCTA surveying.

the last week of May and was removed in August, 1997 and 1998. Temperature loggers measured temperature at 3.25 h intervals. Maximum daily temperature, mean daily temperature, and maximum daily range in temperature between June 1 and August 17, 1997 and 1998, were determined for each reach (Table 2).

Stream gradient (m/km) was determined from U.S. Geological Survey quadrangle maps (1:24,000 scale) following methods recommended by Hamilton and Bergersen (1984). Disturbance within a watershed was assessed using a track-disturbance index collected by the U.S. Army from Land Condition Trend Analysis (LCTA) transects. Fort Riley LCTA transects have been measured annually since 1989 for plant species composition, site and soil characteristics, land management activities, and level of disturbance to the soil and vegetation (Fay 1997). Tazik et al. (1992) provides a detailed description of methodology for LCTA monitoring. Mean percent disturbance scores represented the severity of soil and vegetation disturbance from military training (e.g., tank traffic) and was calculated as the average percent of sample points where physical disturbance occurred during all years of LCTA surveying. Disturbance index values were calculated for each reach by averaging the values within a drainage basin above sites.

Total length of individual macrohabitats was measured. Stream width, depth, current velocity, and substrate particle size were measured at four equidistant points and the midpoint (Platts et al. 1983) along transects spaced at 0.25 and 0.75 times the length for macrohabitats $\leq$ 30 m. If a macrohabitat was > 30 m, transects were placed at 0.25, 0.50, and 0.75 times the length. Mean column velocity was measured at 0.60 times the depth when depths were < 0.75 m with a Marsh-McBirney Flowmate 2000 flowmeter.

When depths were $\geq$ 0.75 m, velocity was measured at 0.20 and 0.80 times the depth and averaged (Buchanan and Somers 1969). Substrate particle size was classified according to a modified Wentworth scale (Cummins 1962), except for the inclusion a bedrock category and pooling of sand categories. In areas where visual estimation was prohibited by depth or turbidity, substrate particle size was estimated by touch with a rod (Platts et al. 1983). Percent canopy closure was measured with a spherical densiometer at four points along each transect (Murphy et al. 1981). One measurement was taken at each stream margin, facing perpendicular to the bank, and two readings were taken at the midpoint, one facing upstream and one facing downstream. Instream cover was defined as any object $\geq$ 0.3 m long and in water $\geq$ 0.3 m deep. Two measurements of length, width, and water depth were collected for all cover. Specific descriptions of cover classifications are provided in Table 2.

Fish sampling and physical habitat measurements were measured separately within each macrohabitat (i.e., pools and riffles). Well-defined run macrohabitats were not encountered and were easily classified as a pool or riffle. One upstream-electrofishing pass was conducted per macrohabitat with a Smith-Root Model 15-C backpack electrofisher equipped with a 120-V generator using pulsed-DC current. Because electrofishing is biased towards large and different species of fish (Bayley and Dowling 1990; Reynolds 1996), seining (bag seine, 7.62-m x 2-m with a 1-m x 1-m bag and 6-mm bar measure mesh) was conducted to supplement electrofishing efforts (Hoyt et al. 1979; Bayley and Dowling 1990). Two seine and two kick-seine hauls were conducted in pool and riffle macrohabitats, respectively. Fifty fish of each species were

measured to the nearest millimeter (total length)–additional fish were counted. Fish that could not be identified in the field were preserved in 10% formalin and identified in the laboratory. Catch per unit effort (C/f) was used to index species and trophic guild abundance (Ney 1993) and was expressed as the number of fish per minute of electrofishing (fish/min) and the number of fish per meter seined (fish/m).

The Shannon-Wiener index was used to assess species (H_S') and trophic guild diversity (H_T'; Ney 1993):

$$H_S' \text{ or } H_T' = -\sum_{i=1}^{S \text{ or } T} n_i / N \ln (n_i / N),$$

where, N = number of individuals in the sample; S or T = number of groups [i.e., species (S), trophic guild (T)] in sample; and n_i = number of individuals in group i in the sample. Each fish species was also placed into a trophic guild based on published information (Table 3; Schlosser 1982b; Gorman 1988; Cross and Collins 1995; Pflieger 1997). The six trophic guilds were benthic-insectivore (BI), generalized-insectivore (GI), herbivore-detritivore (HD), insectivore-piscivore (IP), omnivore (OM), and surface- and water-column insectivore (SW). Schlosser (1982b) provides specific descriptions of trophic guilds. In addition, several species were placed into tolerance categories (i.e., intolerant, tolerant) based on their habitat and reproductive requirements (Table 3; Cross and Collins 1995; Pflieger 1997).

Scales from 10 fish per centimeter length group were collected from central stonerollers, red shiners, creek chubs, and green sunfish (DeVries and Frie 1996). Fish used in the determination of age and growth were not collected independent of

Table 3. Common name, scientific name, trophic guild, tolerance category (T = tolerant; I = intolerant), and longitudinal locations sampled (H = headwater reach, M = mid reach, L = lower reach) for all fish species sampled from streams on Fort Riley Military Reservation during June and July 1997, 1998. Trophic guilds are delineated as: benthic-insectivore (BI), generalized insectivore (GI), herbivore-detritivore (HD), insectivore-piscivore (IP), omnivore (OM), and surface- and water-column insectivore (SW).

Common name	Scientific name	Trophic guild	Tolerance[a]	H	M	L
Central stoneroller	*Campostoma anomalum*	HD	I	X	X	X
Suckermouth minnow	*Phenocobius mirabilis*	BI	I		X	X
River carpsucker	*Carpiodes carpio*	BI				X
White sucker	*Catostomus commersonii*	BI		X	X	X
Shorthead redhorse	*Moxostoma macrolepidotum*	BI				X
Slender madtom	*Noturus exilis*	BI	I		X	X
Stonecat	*Noturus flavus*	BI			X	X
Johnny darter	*Etheostoma nigrum*	BI			X	X
Orangethroat darter	*Etheostoma spectabile*	BI	I	X	X	X
Red shiner	*Cyprinella lutrensis*	GI	T	X	X	X
Common shiner	*Luxilus cornutus*	GI		X	X	X
Redfin shiner	*Lythrurus umbratilis*	GI	I	X	X	X
Topeka shiner	*Notropis topeka*	GI	I		X	X
Southern redbelly dace	*Phoxinus erythrogaster*	GI	I	X		X
Bullhead minnow	*Pimephales vigilax*	GI		X		X
Creek chub	*Semotilus atromaculatus*	GI		X	X	X
Logperch	*Percina caprodes*	GI			X	X
Blackstripe topminnow	*Fundulus notatus*	SW				X
Mosquitofish	*Gambusia affinis*	SW	T		X	
Common carp	*Cyprinus carpio*	OM	T		X	X
Sand shiner	*Notropis ludibundus*	OM			X	X
Bluntnose minnow	*Pimephales notatus*	OM	T	X	X	X
Fathead minnow	*Pimephales promelas*	OM	T	X	X	X
Black bullhead	*Ameiurus melas*	OM	T	X	X	X
Yellow bullhead	*Ameiurus natalis*	OM	T	X	X	X
Channel catfish	*Ictalurus punctatus*	IP	T			X
Green sunfish	*Lepomis cyanellus*	IP	T	X	X	X
Orangespotted sunfish	*Lepomis humilis*	IP	T			X
Bluegill sunfish	*Lepomis macrochirus*	IP	T	X	X	X
Longear sunfish	*Lepomis megalotis*	IP	I		X	X
Spotted bass	*Micropterus punctulatus*	IP	I	X		X
Largemouth bass	*Micropterus salmoides*	IP	T	X	X	X

Table 3. Continued.

White crappie	*Pomoxis annularis*	IP	X
Hybrid 1	*L. cyanellus x L. humilis*	IP	X
Hybrid 2	*L. cyanellus x L. macrochirus*	IP	X
Hybrid 3	*L. megalotis x L. macrochirus*	IP	X
Walleye	*Stizostedion vitreum*	IP	X

[a] Tolerance criteria only established for species that were clearly characterized as intolerant or tolerant.

macrohabitat type (i.e., scales were collected from the first 50 fish, regardless of macrohabitat). Scales were either pressed on acetate slides or mounted between glass slides and examined with a microfiche reader. The Fraser-Lee method was used to determine mean back-calculated length at age for green sunfish using a standardized intercept value of 10 mm (Carlander 1982). A standard intercept value has not been proposed for central stonerollers, creek chubs, or red shiners and the body-scale relationships were weak (i.e., $r^2 < 0.77$); therefore, the direct proportion method was used to calculate mean back-calculated length at age. Age structure of each species was estimated using age-length keys and assessed by determining the proportion of age classes within a sample (DeVries and Frie 1996).

Samples from pools and riffles were assumed to be independent; thus, pool and riffle macrohabitats were analyzed separately. In addition, it is well documented that habitat area and volume (e.g., depth, width) increase longitudinally (Schlosser 1982b; Angermeier and Schlosser 1989; Gordon et al. 1992); therefore, analyses were conducted within each drainage classification (i.e., headwater, mid, and lower reaches) to decrease the influence of spatial variation. Principal component analysis was used to determine if reaches were properly classified. Only principal components with eigenvalues greater than one were used in subsequent analyses (Dillon and Goldstein 1984). Variables for each principal component were retained only if the eigenvector was $\geq |0.40|$.

The mean of each variable from individual macrohabitats was calculated for a site. The mean for sites was used to estimate parameters within a reach (e.g., two headwater sites on Wind Creek) and was used in all analyses. All variables were

examined for normality using univariate plots and the Shapiro-Wilk statistic and for homogeneity of variance using Levene's test (Ott 1993). No variables showed substantial deviations from normality, except phosphorous concentration. Phosphorous concentration values from Forsyth Creek were removed from all analyses due to the influence of an upstream sewage-treatment facility. Scatter and studentized-residual plots for all relationships were examined to identify outliers, linear relationships, and possible curvilinear relationships. Analysis of variance (ANOVA) was used to determine differences in physicochemical habitat and fish community characteristics among reaches by macrohabitat. Multiple comparisons were conducting using least-squared means (Ott 1993).

Correlation analysis was used to examine relations among physicochemical variables. Linear regression analysis was used to model relations between physicochemical habitat and fish community characteristics. Relationships with Pearson's product-moment correlation coefficients (r) $\geq |0.60|$ and P-values ≤ 0.10 were retained for further analysis. Stepwise-multiple regression was used to determine which of the remaining variables explained most of the variation in fish community characteristics. The contribution of individual variables was tested using F-tests, and regression equations were limited to variables which contributed significantly ($P \leq 0.10$) to the model. Models containing more than one independent variable were compared to reduced models by examining Mallows' C_p statistic and reductions in the coefficient of determination (r^2, R^2; Mallows 1973; Ott 1993). The coeficient of variation is presented as adjusted r^2 or R^2. Multicollinearity was analyzed by examining tolerance values and

variance inflation factors as recommended by Sokal and Rohlf (1981). Most predictive models were limited to a single variable because additional variables did not add significantly to the model ($P > 0.10$). All statistical analyses were conducted using SAS (SAS 1996).

Results

Physicochemical Habitat Relations

Principal component 1 accounted for 61% and 69% of the variation in pool and riffle macrohabitats, respectively. Depth (eigenvector = 0.56), width (0.60), and gradient (-0.50) were the main loading variables for pool macrohabitats, while depth (0.55), width (0.54), and velocity (0.55) were the loading variables for riffle macrohabitats (Figure 2). Comparisons of mean principal component scores among reaches (ANOVA; Ott 1993) indicated that mean scores for all reaches were significantly different for pool and riffle macrohabitats ($F = 20.33$, $df = 2,16$, $P = 0.0001$; $F = 7.58$, $df = 2, 14$, $P = 0.005$; respectively). Therefore, the a priori classification of reaches by drainage area and observation correctly classified all reaches as headwaters, mid, or lower reaches as evident by hydrological and stream morphology characteristics.

Mean dissolved oxygen concentration was never below 6.9 mg/L from all reaches, despite temperatures in excess of 20°C (Table 1). Mean dissolved oxygen concentration did not differ significantly among reaches ($F = 1.03$, $df = 2, 16$, $P = 0.3$). Mean reactive phosphorous concentration was generally below 0.50 mg/L and did not differ among reaches ($F = 0.10$, $df = 2, 14$, $P = 0.9$); however, phosphorous

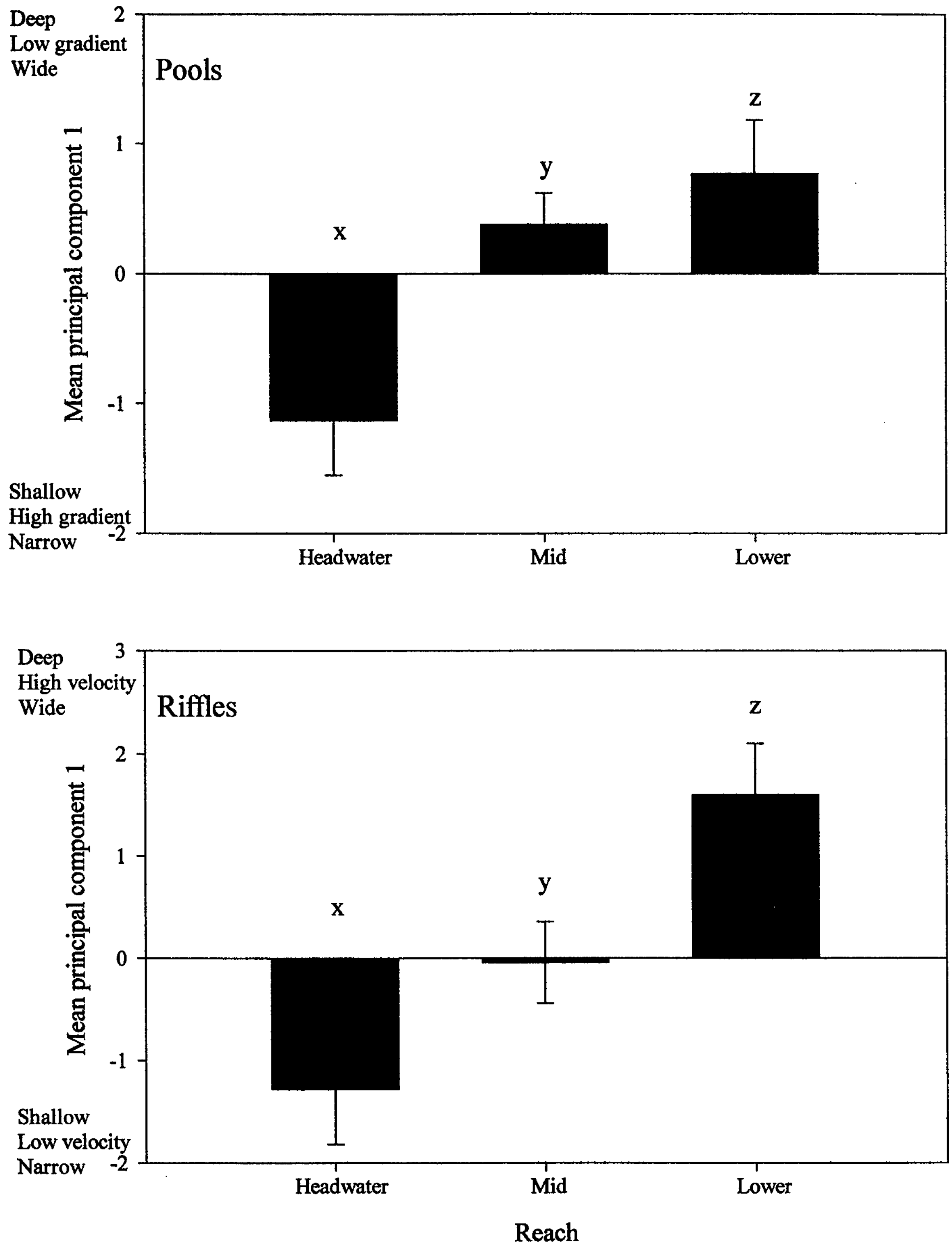

Figure 2. Mean principal component scores for pool and riffle macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter (within macrohabitat) designates no significant difference ($P > 0.10$).

concentrations > 5.0 mg/L were recorded from Forsyth Creek. Mean conductivity was significantly higher in mid reaches than in headwater and lower reaches (F = 3.28, df = 2, 16, P = 0.06) and turbidity was significantly higher in lower reaches (F = 3.68, df = 2, 16, P = 0.04) followed by headwater and mid reaches. Mean daily, maximum daily, and maximum daily range in temperature were similar among reaches (Table 1) and did not differ significantly (F $\leq$ 0.31, df = 2, 13, $P \geq 0.7$). Daily fluctuations of temperature > 10.0 °C were recorded at several sites. Mean percent disturbance in headwater watersheds was significantly higher than in mid and lower-reach watersheds (F = 4.12, df = 2, 16, P = 0.03). Most disturbance from military training occurred in the uplands within the interior portion of the installation, which accounts for the high percent disturbance in headwater watersheds.

One-hundred and ninety-one pool and 171 riffle macrohabitats were sampled during June and July, 1997 and 1988, to represent the eight headwater, six mid, and five lower reaches. Mean width, depth, and velocity in pool (F $\geq$ 3.51, df = 2, 16, $P \leq 0.05$) and riffle (F $\geq$ 2.97, df = 2, 14, $P \leq 0.04$) macrohabitats differed significantly among reaches (Figure 3). Riparian vegetation was abundant at most sample sites and often extended for several hundred meters from the stream margins. Consequently, mean canopy did not differ significantly among reaches in both pool (F = 0.07, df = 2, 16, P = 0.9) and riffle (F = 1.21, df = 2, 14, P = 0.3) macrohabitats (Figure 3).

The proportion of silt substrate in pool macrohabitats was significantly higher in headwater reaches compared to mid and lower reaches (Table 4; F = 3.72, df = 2,16, P = 0.04). Percent bedrock substrate was significantly highest in lower reaches (F = 3.22, df

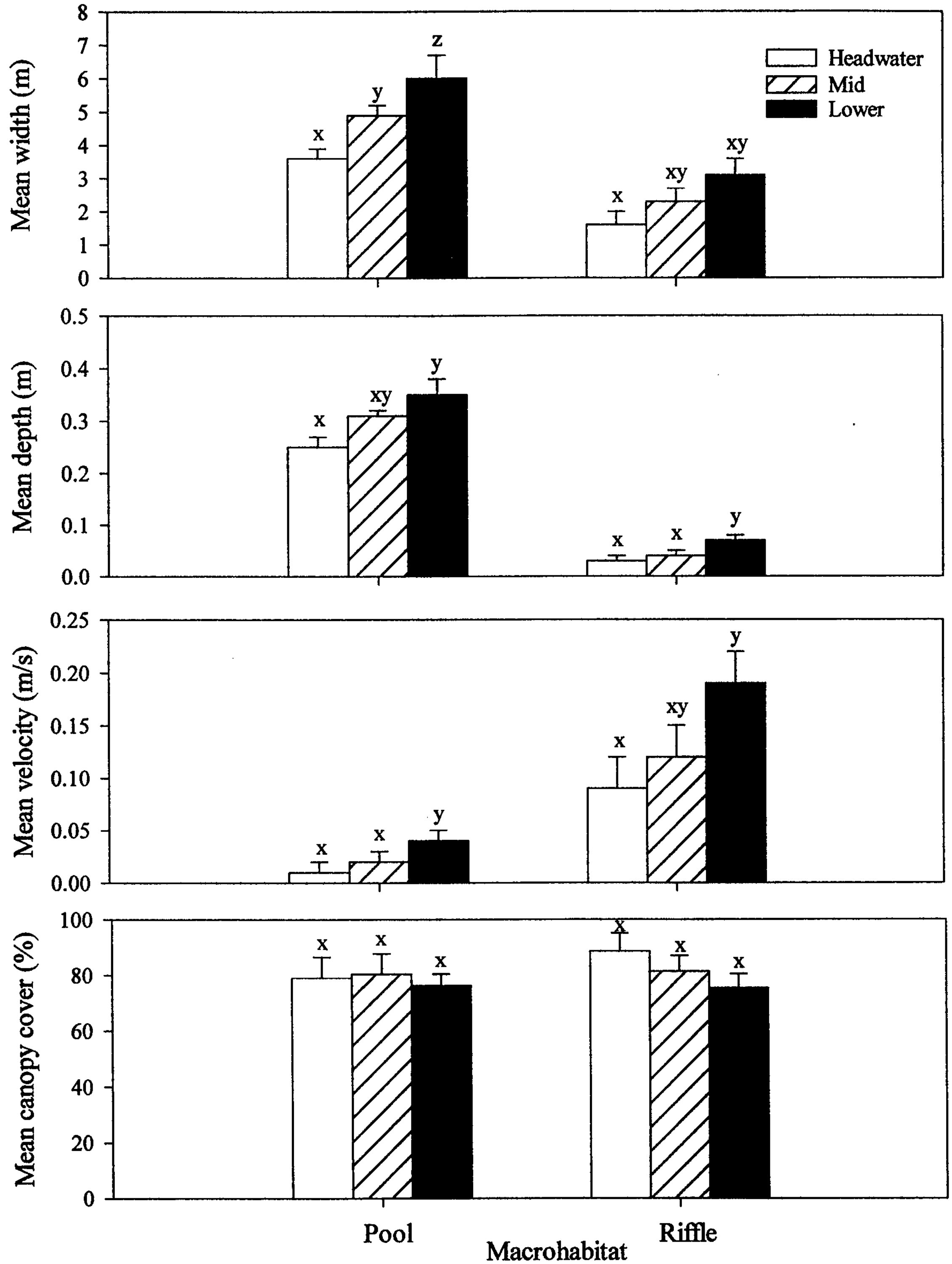

Figure 3. Mean width, depth, current velocity, and percent canopy cover for pool and riffle macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter (within macrohabitat; pool or riffle) designates no significant difference ($P > 0.10$).

Table 4. Mean percent substrate by macrohabitat for streams on Fort Riley Military Reservation sampled during June and July 1997, 1998. Number in parenthesis represents standard error. Values with the same letter indicate no significant difference ($P > 0.10$). Comparisons were among reaches by macrohabitat (P=pool, R=riffle) and substrate category.

		Substrate category						
Reach	Macrohabitat	Bedrock	Boulder	Clay	Cobble	Gravel	Pebble	Silt
Headwater	P	0^{x} (0)	2.4^{x} (1.1)	12.5^{x} (5.0)	5.1^{x} (1.7)	9.2^{x} (2.7)	4.8^{x} (1.6)	65.4^{x} (6.0)
Mid	P	1.5^{x} (0.9)	5.4^{x} (2.9)	6.5^{x} (2.9)	10.3^{x} (1.7)	24.5^{y} (4.9)	13.5^{y} (2.6)	38.4^{y} (8.6)
Lower	P	7.2^{y} (4.4)	5.3^{x} (2.7)	9.2^{x} (3.0)	10.7^{x} (4.8)	16.9^{xy} (2.5)	14.0^{y} (5.8)	36.5^{y} (13.2)
Headwater	R	0^{x} (0)	6.3^{x} (2.4)	0.6^{x} (0.5)	36.2^{x} (9.2)	10.8^{x} (5.6)	22.2^{x} (6.6)	23.8^{x} (16.6)
Mid	R	0.4^{x} (0.3)	2.3^{x} (0.9)	0.2^{x} (0.1)	36.3^{x} (7.8)	13.1^{x} (1.7)	47.1^{y} (6.8)	0.7^{x} (0.3)
Lower	R	1.7^{x} (1.2)	5.8^{x} (1.2)	1.3^{x} (0.9)	44.6^{x} (3.8)	12.5^{x} (3.3)	30.8^{y} (3.6)	3.2^{x} (2.1)

= 2, 16, $P = 0.06$). Silt and cobble substrate were most abundant in riffle macrohabitats from headwater reaches; whereas, the dominant substrate in mid and lower reaches was cobble and pebble. Only percent pebble substrate differed among reaches (F = 4.52, df = 2, 14, $P = 0.03$).

Aquatic macrophytes, primarily Lemnaceae and *Potamogeton* spp., were the most abundant form of instream cover in pool macrohabitats for headwater and mid reaches and did not differ significantly (Table 5; F = 1.01, df = 2, 16, $P = 0.3$). Area of total woody debris was the dominant cover type in lower reaches, but did not differ significantly from other reaches (F = 0.81, df = 2, 16, $P = 0.4$). For riffle macrohabitats, total woody debris was the most common form of instream cover in headwater and lower reaches. Aquatic vegetation, rootwad, and undercut-bank habitat were only sampled in riffle macrohabitats from mid reaches. Despite the differences in area of instream cover, no significant differences were found (F ≤ 1.53, df = 2, 14, $P \geq 0.3$).

I surmised that instream habitat was affected by landscape-level conditions; thus, percent disturbance and riparian canopy cover were analyzed with instream habitat variables. In pool macrohabitats, percent disturbance was positively correlated with percent silt in headwater and mid reaches (Figure 4). Percent canopy cover was negatively correlated with area of aquatic vegetation and explained 61% - 90% of the variation in all reaches (Figure 5). Area of aquatic vegetation never exceeded 2 m^2/ha when canopy cover was ≥75%. Percent canopy cover was also positively correlated with area of bank roots (headwater and mid) and rootwads (mid) using a second-order polynomial (Figure 5). Area of woody debris (i.e., bank root, rootwad) did not exceed 20

Table 5. Amount of cover (m^2/ha) in streams on Fort Riley Military Reservation sampled during June and July 1997, 1998. Number in parenthesis represents standard error. Values with the same letter indicate no significant difference ($P > 0.10$). Comparisons were among reaches by macrohabitat (P=pool, R=riffle) and cover category.

		Cover category							
Reach	Macrohabitat	Aquatic vegetation	Branch complex	Bank root	Log	Log complex	Rootwad	Undercut bank	Total woody debris
Headwater	P	1165.6^x	20.1^x	35.9^x	17.1^x	354.2^x	70.5^x	63.1^x	497.8^x
		(912.4)	(8.3)	(11.9)	(7.8)	(106.3)	(23.5)	(40.1)	(116.5)
Mid	P	2335.3^x	83.0^x	69.1^x	17.7^x	133.1^x	29.9^x	55.3^x	332.8^x
		(1186.9)	(30.4)	(36.9)	(8.7)	(47.2)	(14.0)	(33.2)	(62.4)
Lower	P	323.3^x	55.5^x	10.4^x	17.9^x	359.2^x	14.8^x	8.5^x	457.9^x
		(243.1)	(29.4)	(5.7)	(5.8)	(60.9)	(7.6)	(6.1)	(64.3)
Headwater	R	0^x	26.3^x	1.3^x	17.5^x	195.3^x	0^x	0^x	240.5^x
		(0)	(21.8)	(1.3)	(12.9)	(114.7)	(0)	(0)	(147.8)
Mid	R	254.4^x	33.1^x	16.5^x	35.3^x	111.8^x	9.9^x	3.4^x	206.5^x
		(189.1)	(22.0)	(16.5)	(32.9)	(47.1)	(9.9)	(3.4)	(43.9)
Lower	R	0^x	0^x	0^x	14.1^x	272.4^x	0^x	0^x	281.2^x
		(0)	(0)	(0)	(7.2)	(173.1)	(0)	(0)	(181.3)

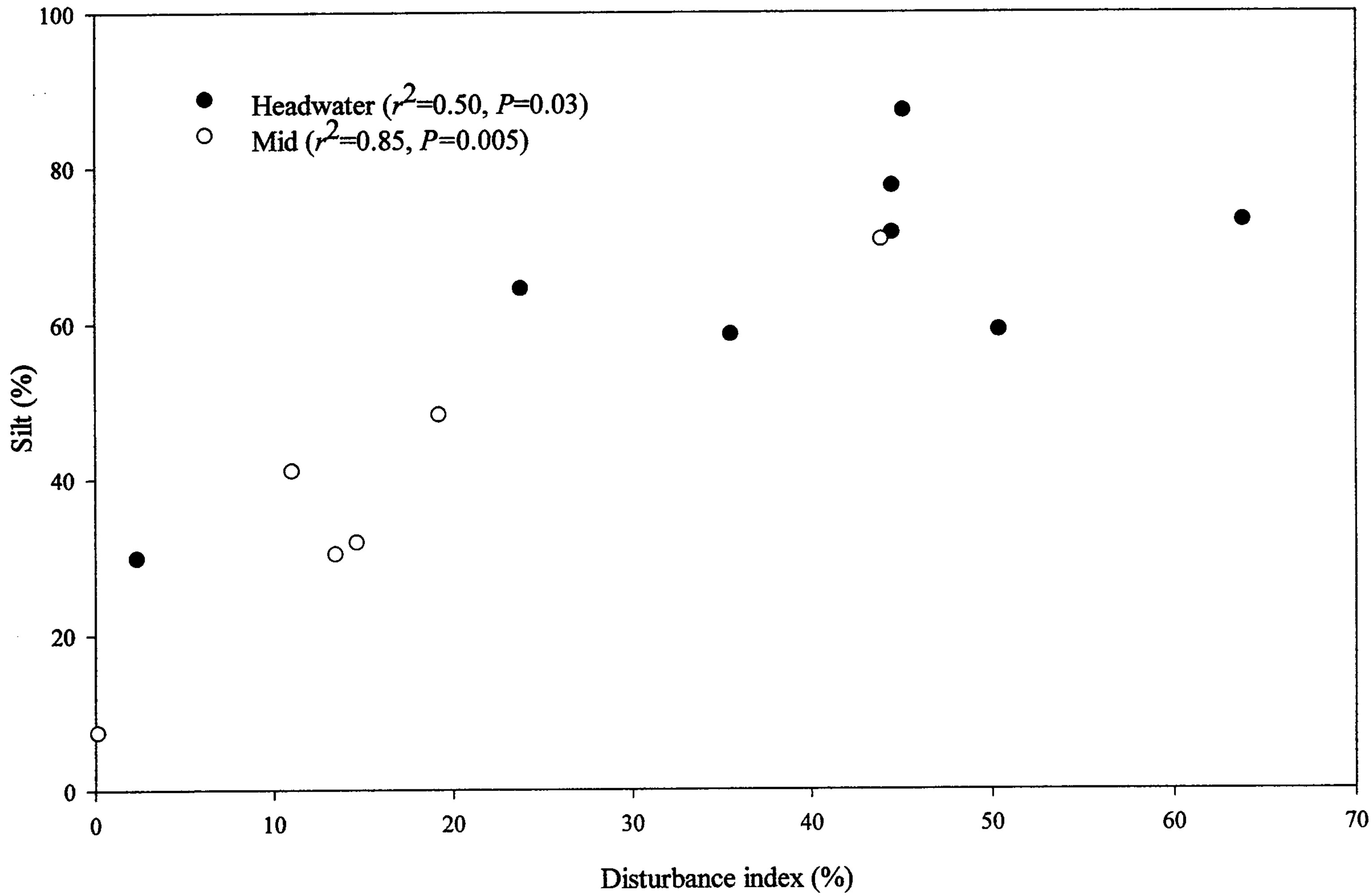

Figure 4. Relationships between silt (%) and disturbance (%) in pool macrohabitats for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998.

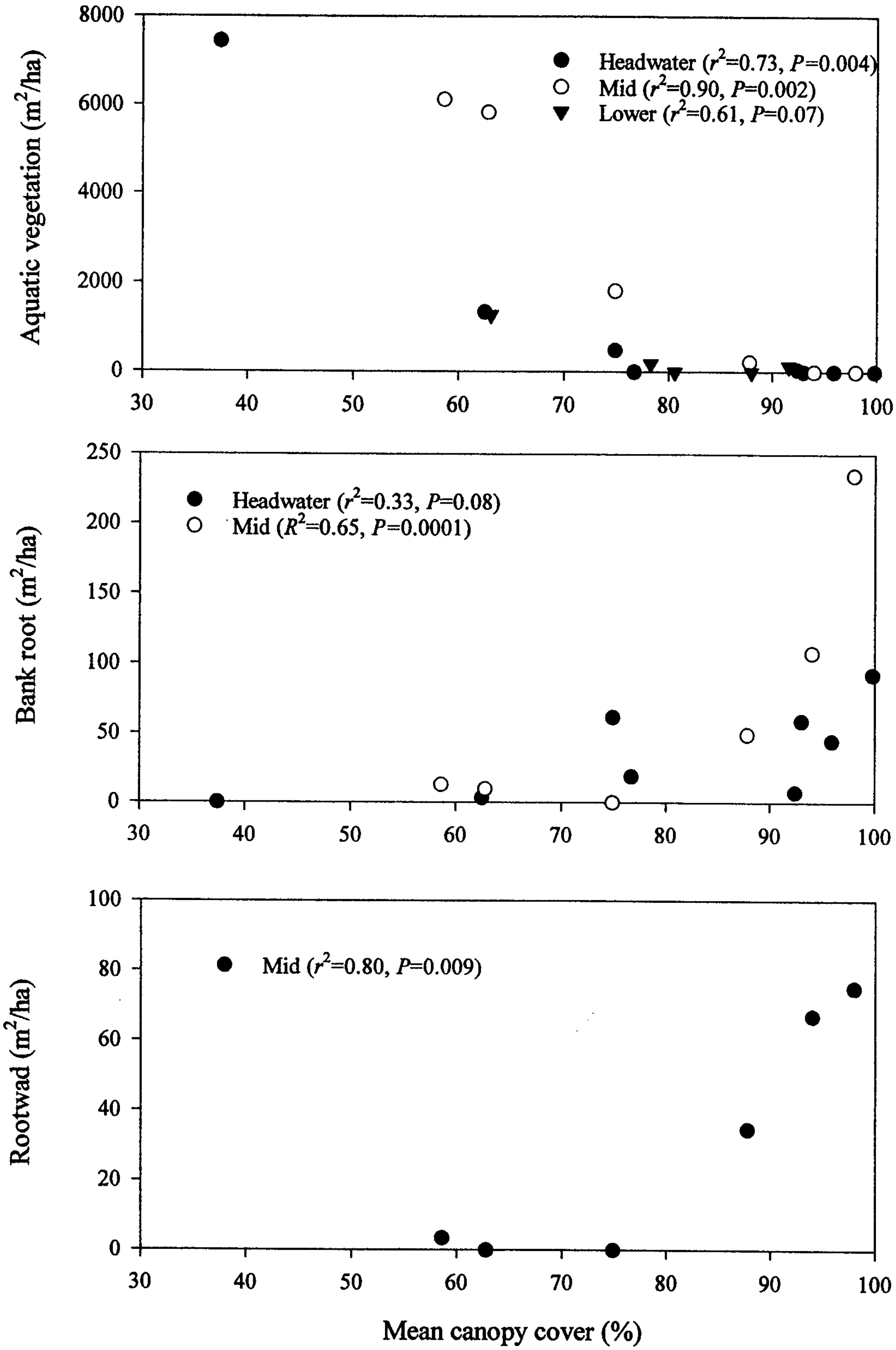

Figure 5. Relationships between aquatic vegetation (m²/ha), bank roots (m²/ha), and rootwads (m²/ha) and canopy cover (%) in pool macrohabitats for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998.

m^2/ha until canopy cover was 75%. Percent canopy cover in mid reaches was also correlated with area of bank roots ($r = 0.80$, $P = 0.05$), area of total woody debris ($r = 0.89$, $P = 0.01$), mean daily temperature ($r = -0.71$, $P = 0.09$), maximum daily temperature ($r = -0.79$, $P = 0.05$), and maximum daily range in temperature ($r = -0.88$, $P = 0.02$). In riffle macrohabitats, percent disturbance was negatively correlated with mean depth ($r = -0.85$, $P = 0.03$), width ($r = -0.73$, $P = 0.09$), and velocity ($r = -0.89$, $P = 0.01$) in headwater reaches. Aquatic vegetation was only sampled in mid reaches and was positively correlated with percent disturbance ($r = 0.89$, $P = 0.01$). Percent disturbance and canopy cover were not significantly correlated with physicochemical variables in lower stream reaches ($P > 0.10$).

Fish-Habitat Relations

Fish community indicies.– Approximately 19,850 individual fishes representing 35 taxa and 7 families were sampled from all reaches and macrohabitats. Cyprinidae was the most abundant family comprising 78% of the total number of fishes. Forty-five percent of the fishes sampled were red shiners, central stonerollers, and bluntnose minnows. The second most abundant family was Centrarchidae, which comprised 11% of the sampled fishes, and was dominated by green sunfish, largemouth bass, and bluegills.

Species richness, species diversity, and trophic guild diversity varied spatially and by macrohabitat (Figure 6). Mean number of species in pool macrohabitats varied from 1 to 7 in headwater, 3 to 8 in mid, and 7 to 14 in lower reaches. Species diversity varied

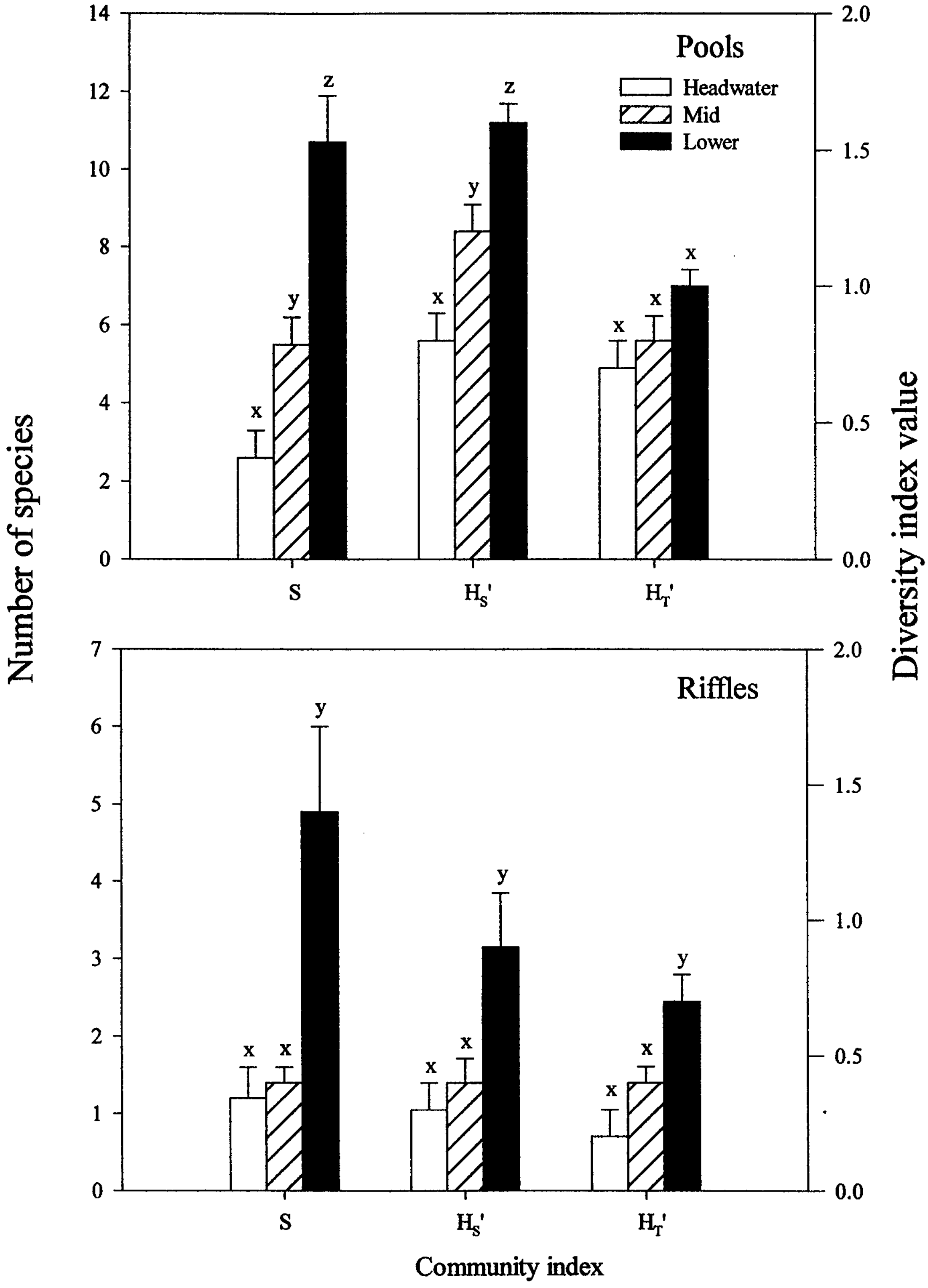

Figure 6. Species richness (S), species diversity (H_S'), and trophic guild diversity (H_T') for pool and riffle macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter designates no significant difference ($P > 0.10$)

from 0 to 1.3 in headwater, 0.7 to 1.5 in mid, and 1.4 to 1.9 in lower reaches. Trophic guild diversity varied from 0 to 1.2 in headwater, 0.3 to 0.8 in mid, and 0.7 and 1.1 in lower reaches. Species richness (F = 21.13, df = 2, 16, $P = 0.0001$) and species diversity (F = 8.62, df = 2, 16, $P = 0.02$) in pool macrohabitats were significantly higher in lower reaches compared to mid and headwater reaches (Figure 6). Riffle macrohabitats contained fewer species and were less diverse than pool macrohabitats. The mean number of species never exceeded 3 in headwater and mid reaches, but varied from 2 to 8 in lower reaches. Species diversity varied from 0 to 0.6 in headwater, 0.2 to 0.9 in mid, and 0.6 to 1.5 in lower reaches and trophic guild diversity never exceeded 1.1 for all reaches. Species richness (F = 9.90, df = 2, 14, $P = 0.002$), species diversity (F = 6.41, df = 2, 14, $P = 0.01$), and trophic guild diversity (F = 5.04 = 2, 14, $P = 0.02$) in riffle macrohabitats were significantly higher in lower reaches than in headwater and mid reaches (Figure 6).

Several physicochemical variables were correlated with species richness, species diversity, and trophic guild diversity (Table 6). In pool macrohabitats, species richness was weakly correlated with percent gravel in headwater reaches ($r = 0.74$, $P = 0.03$) and percent disturbance in mid-reach watersheds ($r = 0.72$, $P = 0.09$). In general, physicochemical variables were better correlated with species diversity and trophic guild diversity (Table 6). For example, 91% of the variation in species diversity at headwater reaches was explained by area of aquatic vegetation and branch complex. Similarly, 75% of the variation in trophic guild diversity at headwater reaches was explained by area of aquatic vegetation and branch complex. Fifty-seven percent of the significant

Table 6. Species richness (S), species diversity (H_S'), and trophic guild divesity (H_T') and significantly correlated variables ($P \leq 0.10$) by reach (H=headwater, M=mid, L=lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Equation is the best relationship determined by multiple regression analysis.

Macrohabitat	Community index	Reach	Correlated variables (correlation coefficient)	Equation	r^2 or R^2
Pool					
	Species richness	H	gravel (0.74)	S = 0.77 + 0.20 (gravel)	0.47
		M	disturbance (0.72)	S = 3.99 + 0.090 (disturbance)	0.42
	Species diversity	H	aquatic vegetation (-0.75), branch complex (0.80)	H_S' = 0.69 - 0.000092 (aquatic vegetation) + 0.011 (branch complex)	0.91
		M	disturbance (0.75)	H_S' = 0.92 + 0.01 (disturbance)	0.47
		L	canopy cover (0.89)	H_S' = 0.54 + 0.014 (canopy cover)	0.63
	Trophic guild diversity	H	aquatic vegetation (-0.75), branch complex (0.71)	H_T' = 0.60 - 0.000078 (aquatic vegetation) + 0.0079 (branch complex)	0.75
		L	mean velocity (0.84), branch complex (-0.81)	H_T' = 0.81 + 3.85 (mean velocity)	0.60
Riffle					
	Species richness	H	mean width (0.89), mean velocity (0.77)	S = -0.49 + 1.06 (mean width)	0.74
		L	mean width (0.94), phosphorous (0.92)	S = -2.03 + 2.24 (mean width)	0.84
	Species diversity	M	mean width (-0.80), boulder (-0.80)	H_S' = 0.94 - 0.22 (mean width)	0.54
		L	mean width (0.92), phosphorous (0.86)	H_S' = -0.11 + 0.35 (mean width)	0.80
	Trophic guild diversity	H	mean width (0.80)	H_T' = -0.14 + 0.24 (mean width)	0.56
		M	mean width (-0.88)	H_T' = 0.73 - 0.16 (mean width)	0.73
		L	mean width (0.89), phosphorous (0.88)	H_T' = -0.019 + 0.22 (mean width)	0.73

correlations among species richness, species diversity, and trophic guild diversity and physicochemical variables were associated with riparian area variables (i.e., canopy cover, branch complex). Substrate type was only significantly correlated with species richness in headwater reaches. Species richness and species diversity in mid reaches were only correlated with percent disturbance in the watershed (Table 6). Fish community indices were correlated with different physicochemical variables in riffle macrohabitats. For example, mean width explained 54% - 80% of the variation in species richness, species diversity, and trophic guild diversity (Table 6). In contrast to pool macrohabitats, riparian area variables were not significantly correlated ($P > 0.10$) with fish community indices (Table 6).

Catch per unit effort by trophic guild and tolerance category.–Catch per unit effort (C/f) of trophic guilds in pool macrohabitats was highest for lower reaches, except for herbivore-detritivores (Figure 7). Only C/f of generalized-insectivores was significantly different among reaches ($F = 4.08$, df = 2, 16, $P = 0.03$). Herbivore-detritivores (i.e., central stonerollers), generalized-insectivores, and omnivores were most abundant in all reaches. Benthic-insectivores were also sampled, but their abundance was expressed as fish/m of seining. Therefore, C/f of benthic-insectivores is not directly comparable with other trophic guilds. Catch per unit effort of tolerant and intolerant species was significantly higher for lower reaches than headwater and mid reaches (Figure 8; $F = 3.56$, df = 2, 16, $P = 0.05$; $F = 9.93$, df = 2, 16, $P = 0.001$; respectively). Tolerant species were generally more abundant than intolerant species, except in lower reaches–likely due to high C/f of redfin shiners, longear sunfish, and suckermouth

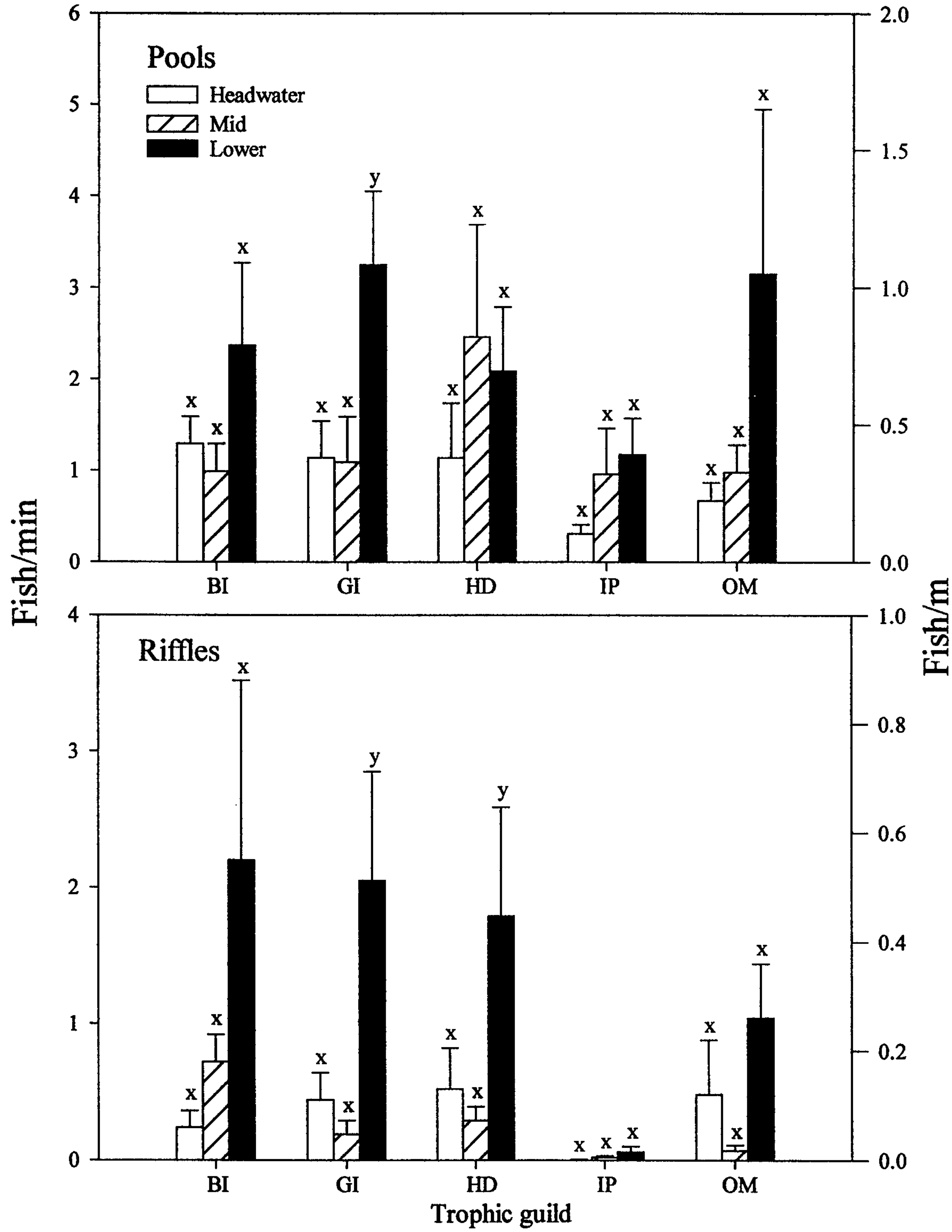

Figure 7. Catch per unit effort by trophic guild (BI=benthic-insectivore, GI=generalized-insectivore, HD=herbivore-detritivore, IP=insectivore-piscivore, OM=omnivore) for pool and riffle macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter (within macrohabitat) designates no significant difference ($P > 0.10$). Catch per unit effort is expressed as fish/min for all trophic guilds, except for benthic-insectivores which is expressed as fish/m.

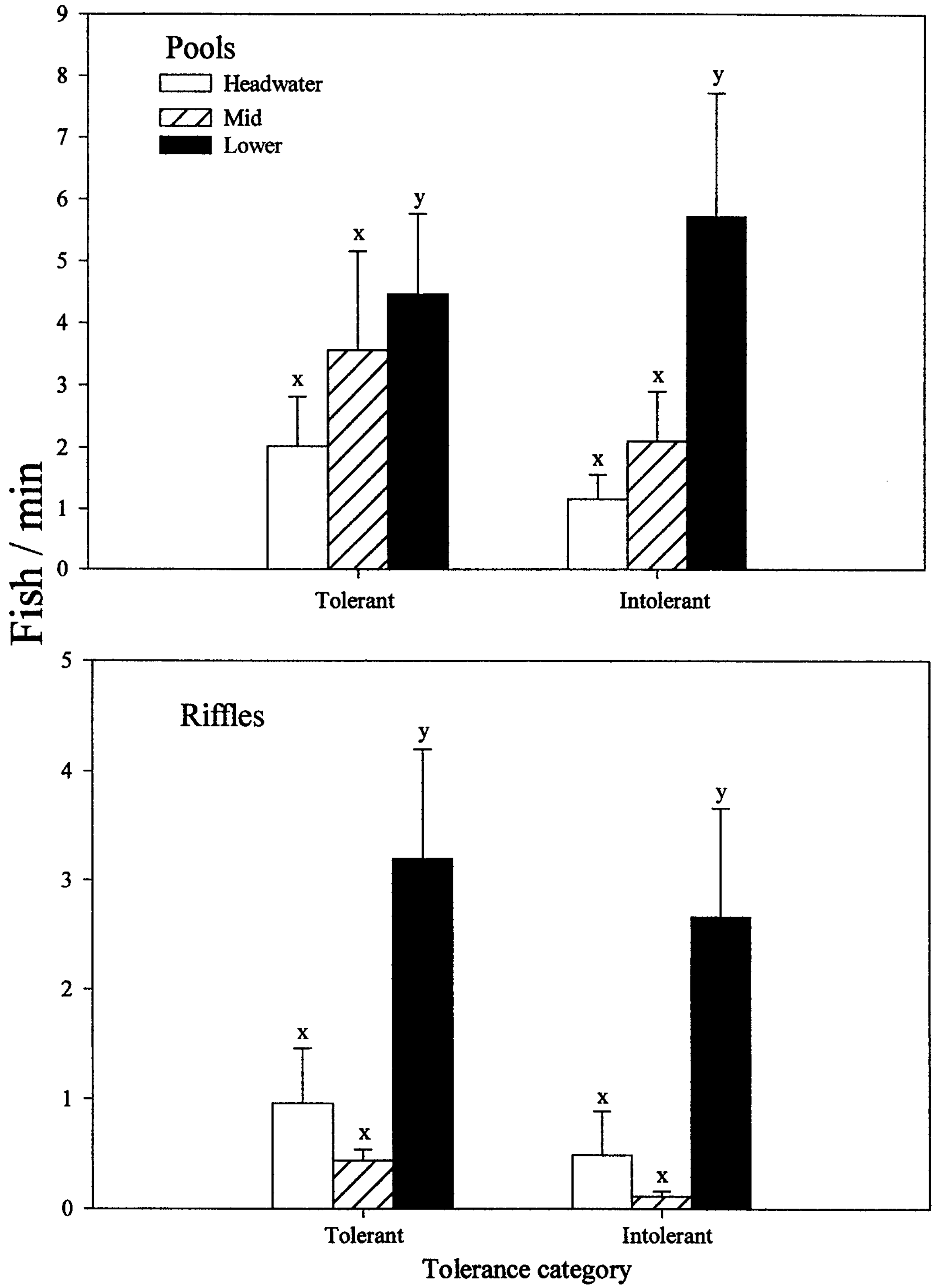

Figure 8. Catch per unit effort by tolerance category (tolerant, intolerant) for pool and riffle macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter (within macrohabitat) designates no significant difference ($P > 0.10$).

minnows in lower reaches.

Similar to pool macrohabitats, C/f of trophic guilds in riffles was highest in lower reaches. Herbivore-detritivores and generalized-insectivores were the most abundant trophic guild sampled by electrofishing from lower and mid reaches; whereas, herbivore-detritivores and omnivores were most abundant in the headwaters. Benthic-insectivores were the most frequently sampled trophic guild in all reaches; however, their abundance is not directly comparable to other trophic guilds due to differences in gear (i.e., electrofishing versus seining). Insectivore-piscivores were rarely collected in riffle macrohabitats; thus, they were removed from further analyses. Catch per unit effort of tolerant and intolerant species was significantly higher for lower reaches than headwater and mid reaches (Figure 8; $F = 5.32$, $df = 2, 14$, $P = 0.01$; $F = 3.68$, $df = 2, 14$, $P = 0.05$; respectively). Tolerant species were more abundant than intolerant species in all reaches.

Several physicochemical variables were correlated with C/f of trophic guilds and tolerance categories (Table 7). In pool macrohabitats, substrate type was an important physicochemical variable. For example, percent gravel was a significant correlate in 80% of the relationships for headwater reaches and explained 44% - 73% of the variation in C/f of generalized-insectivores, insectivore-piscivores, omnivores, and tolerant species (Table 7). Fifty percent of the significant correlations in mid reaches were associated with percent disturbance or percent silt (Table 7). Percent disturbance explained 58% - 93% of the variation in C/f of insectivore-piscivores, omnivores, and tolerant species, and percent silt was weakly correlated with C/f of insectivore-piscivores ($r = 0.66$, $P =$

Table 7. Catch per unit effort of trophic guilds and tolerance categories and significantly correlated variables ($P \leq 0.10$) by reach (H=headwater, M=mid, L=lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Equation is the best relationship determined by mulitple regression analysis.

Macrohabitat	Guild	Reach	Correlated variables (correlation coefficient)	Equation	r^2 or R^2
Pool					
	Benthic-insectivore	M	bank root (0.87)	BI = 0.026 + 0.0044 (bank root)	0.69
		L	mean velocity (0.88), phosphorous (0.93)	BI = -0.49 + 8.79 (mean velocity) + 1.89 (phosphorous)	0.96
	Generalized-insectivore	H	gravel (0.66), pebble (0.82)	GI = 0.27 + 0.21 (pebble)	0.61
		M	total woody debris (0.92), mean velocity (0.92), boulder (0.79)	GI = -1.45 + 0.0076 (total woody debris)	0.80
	Insectivore-piscivore	H	gravel (0.86), silt (0.66)	IP = -0.15 + 0.05 (gravel)	0.70
		M	disturbance (0.97), gravel (0.86), silt (0.66)	IP = -0.41 + 0.080 (disturbance)	0.93
		L	mean width (0.87), mean depth (0.86)	IP = -1.47 + 0.44 (mean width)	0.69
	Omnivore	H	gravel (0.79), total woody debris (0.68), log complex (0.71)	OM = -0.19 + 0.036 (gravel) + 0.0009 (log complex)	0.66
		M	disturbance (0.81)	OM = 0.19 + 0.046 (disturbance)	0.58
		L	mean width (0.93), boulder (0.82)	OM = -10.17 + 2.20 (mean width)	0.82
	Intolerant	H	disturbance (-0.72), log (0.64), rootwad (0.89), mean velocity (0.96)	INT = 0.37 + 135.41 (mean velocity)	0.92
		M	mean velocity (0.97), boulder (0.98)	INT = 0.56 + 0.56 (boulder)	0.96
		L	rootwad (-0.86)	INT = 6.57 - 0.14 (rootwad)	0.65
	Tolerant	H	gravel (0.87)	TOL = -0.17 + 0.13 (gravel)	0.73
		M	disturbance (0.89)	TOL = -0.015 + 0.12 (disturbance)	0.71
		L	mean width (0.95)	TOL = -13.08 + 3.10 (mean width)	0.88

Table 7. Continued.

Riffle					
	Benthic-insectivore	H	disturbance (-0.95), mean depth (0.95), mean width (0.85), mean velocity (0.96), branch complex (0.87), log (0.98)	BI = 0.15 - 0.0028 (disturbance) + 0.00065 (branch complex)	0.96
		M	log complex (0.90), gravel (0.89)	BI = 0.073 + 0.00093 (log complex)	0.77
		L	boulder (0.90)	BI = -0.84 + 0.24 (boulder)	0.74
	Generalized-insectivore	M	phosphorous (0.90)	GI = -0.33 + 1.32 (phosphorous)	0.76
	Omnivore	H	canopy cover (-0.94), pebble (0.83)	OM = 6.01 - 0.062 (canopy cover)	0.86
		M	disturbance (0.85)	OM = -0.03 + 0.0058 (disturbance)	0.64
		L	mean velocity (0.84)	OM = -1.37 + 12.28 (mean velocity)	0.60
	Tolerant	H	canopy cover (-0.94)	TOL = 6.01 - 0.062 (canopy cover)	0.86
		M	disturbance (0.90), canopy cover (-0.78)	TOL = -0.03 + 0.0082 (disturbance)	0.76
		L	phosphorous (0.86)	TOL = -0.51 + 6.56 (phosphorous)	0.65

0.03). Similar to fish community index-physicochemical habitat relations, riparian area variables (i.e., bank root, total woody debris) were significant correlates in pool macrohabitats. For example, 69% of the variation in C/f of benthic-insectivores and 80% of the variation in C/f of generalized-insectivores at mid reaches was explained by area of bank root and total woody debris, respectively. Catch per unit effort of fishes in trophic guilds and tolerance categories at lower reaches were best correlated with hydrological (i.e., mean velocity) or stream morphological (i.e., mean width, mean depth) variables. Mean width was the most common physicochemical variable and explained 69% - 88% of the variation in C/f of insectivore-piscivores, omnivores, and tolerant species in lower reaches (Table 7). The surface- and water-column insectivore trophic guild was comprised of two species which were only collected from a few locations; thus, they were removed from the analyses. The herbivore-detritivore trophic guild was comprised only of central stonerollers; therefore, physicochemical habitat relations are presented with individual species analysis.

In general, C/f of fishes in trophic guilds and tolerance categories were correlated with different physicochemical variables in riffle macrohabitats. For example, riparian area variables (i.e., canopy cover, branch complex, log) were significantly correlated with C/f of fishes in all trophic guilds and tolerance categories at headwater reaches (Table 7); whereas, percent gravel appeared to be most influential in pool macrohabitats. Percent disturbance explained 88% of the variation in C/f of benthic-insectivores at headwater reaches, and 64% - 76% of the variation in C/f of omnivores and tolerant species at mid reaches. Similar to pool macrohabitats, significant physicochemical

variables in lower reaches differed from headwater and mid reaches. No significant correlations were found for C/f of intolerant species ($P > 0.10$). Correlation analysis was not conducted for C/f of insectivore-piscivores due to low frequency of occurrence in riffle macrohabitats.

Catch per unit effort by species.–Central stonerollers and creek chubs were sampled from 95% of the reaches, while fathead minnows and green sunfish were sampled from 84% of the reaches. All species sampled in headwater reaches were also sampled in lower reaches (Table 3); however, several species (e.g., suckermouth minnow, logperch) were only sampled in mid and lower reaches, or lower reaches (e.g., river carpsucker, walleye). Catch per unit effort of individual species in pool macrohabitats generally increased from headwater to lower reaches (Figure 9), but only C/f of red shiners ($F = 6.86$, df = 2, 16, $P = 0.007$), suckermouth minnows ($F = 2.82$, df = 2, 16, $P = 0.08$), bluntnose minnows ($F = 3.05$, df = 2, 16, $P = 0.07$), and bluegills ($F = 7.98$, df = 2, 16, $P = 0.003$) were significantly different. Analysis of variance and correlation analyses were only conducted on species presented in Figure 9 because other species were sampled from a few locations (i.e., ≤ 3) or C/f was low (i.e., ≤ 0.004 fish/min or ≤ 0.03 fish/m). Central stonerollers, creek chubs, slender madtoms, and orangethroat darters were the most abundant species in riffle macrohabitats. However, only C/f of central stonerollers and slender madtoms differed significantly among reaches (Figure 10; $F = 2.77$, df = 2, 14, $P = 0.09$; $F = 3.05$, df = 2,14, $P = 0.07$; respectively).

Numerous physicochemical variables were correlated with C/f of species in pool

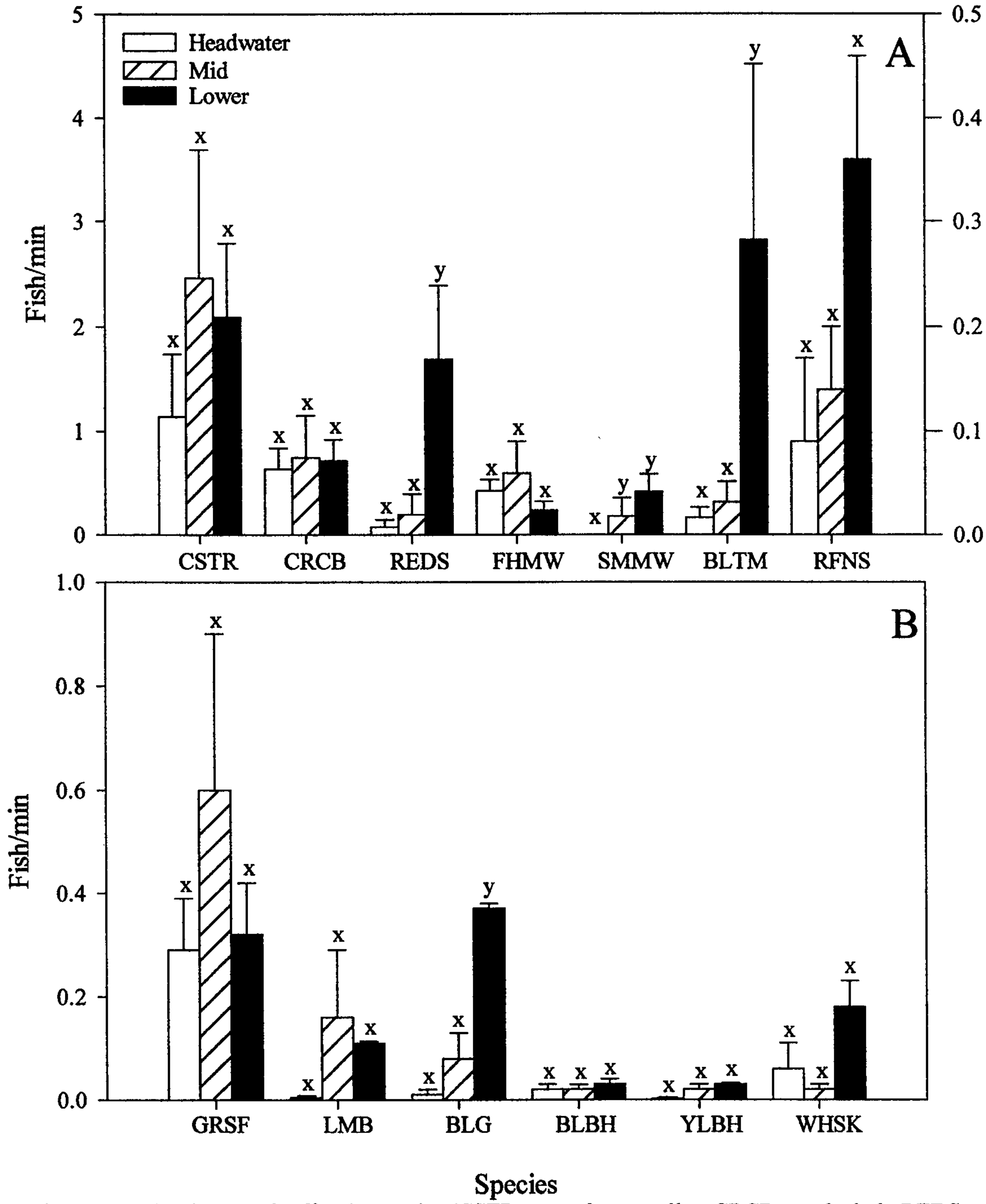

Figure 9. Catch per unit effort by species (CSTR=central stoneroller, CRCB=creek chub, REDS=red shiner, FHMW=fathead minnow, SMMW=suckermouth minnow, BLNT=bluntnose minnow, RFNS=redfin shiner, GRSF=green sunfish, LMB=largemouth bass, BLG=bluegill, BLBH=black bullhead, YLBH=yellow bullhead, WHSK=white sucker) from pool macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter designates no significant difference (P>0.10). Catch per unit effort is expressed as fish/min except for redfin shiners which is expressed as fish/m. Graphs are separated by family (A=Cyprinidae, B=Centrarchidae, Ictaluridae, Catostomidae).

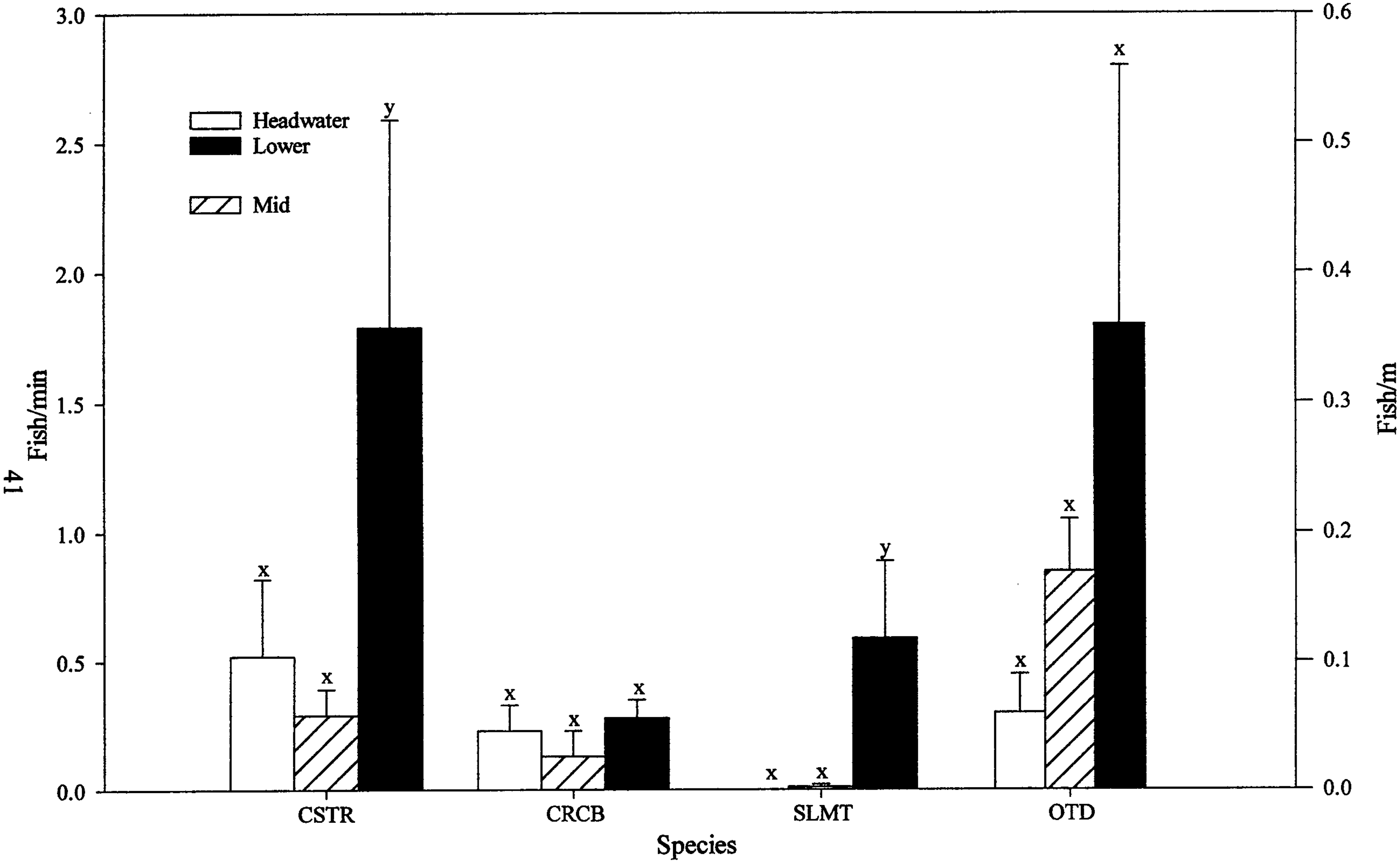

Figure 10. Catch per unit effort by species (CSTR=central stoneroller, CRCB=creek chub, SLMT=slender madtom, OTD=orangethroat darter) for riffle macrohabitats by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter designate no significant difference ($P > 0.10$). Catch per unit effor is expressed as fish/min for all species except for orangethroat darters which is expressed as fish/m.

macrohabitats (Table 8). Substrate variables were significantly correlated in 64% of all relationships. Although percent gravel was significantly correlated with species richness and C/f of generalized-insectivores, insectivore-piscivores, omnivores and tolerant species in headwater reaches, percent gravel was only correlated with C/f of green sunfish (Table 8). Conversely, substrate type was significantly correlated in 75% of the relationships in mid reaches and all of the relationships in lower reaches. Percent silt was the most common substrate type and explained 54% - 57% of the variation in C/f of green sunfish, largemouth bass, and bluntnose minnows at mid reaches and 67% - 81% of the variation in C/f of black bullheads, largemouth bass, redfin shiners, and yellow bullheads at lower reaches. Percent disturbance was often correlated with C/f of species that were also correlated with percent silt. For example, percent disturbance and percent silt were both positively correlated with C/f of green sunfish, largemouth bass, and bluntnose minnows at mid reaches and C/f of black bullheads, redfin shiners, and yellow bullheads at lower reaches (Table 8). Riparian area variables (i.e., rootwad, total woody debris, bank root) explained 32% - 66% of the variation in C/f of central stonerollers, creek chubs, and fathead minnows in headwater reaches and 55% - 92% of the variation in C/f of central stonerollers, creek chubs, and redfin shiners in lower reaches. Riparian area variables (i.e., total woody debris) were only correlated with C/f of creek chubs in mid reaches. Hydrological (i.e., mean velocity) and stream morphological (i.e., mean width) variables were significantly correlated with community indices and C/f of fishes in trophic guilds and tolerance categories at lower reaches. Similar trends were found at lower reaches with regards to C/f of species. For example, mean velocity explained 92%

Table 8. Catch per unit effort of species and significantly correlated variables ($P \leq 0.10$) in pool and riffle macrohabitat by reach (H=headwater, M=mid, L=lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Equation is the best relationship determined by multiple regression analysis.

Macrohabitat	Species	Reach	Correlated variables (correlation coefficient)	Equation	r^2 or R^2
Pool					
	Central stoneroller	H	disturbance (-0.85), mean velocity (0.97), rootwad (0.84)	CSTR = -0.26 + 115.07 (mean velocity)	0.94
		M	mean velocity (0.91), boulder (0.86)	CSTR = -1.35 + 193.22 (mean velocity)	0.79
		L	rootwad (0.81), gravel (-0.91)	CSTR = 6.82 -0.27 (gravel)	0.79
	Creek chub	H	rootwad (0.64),	CRCB = 0.14 + 0.0069 (rootwad)	0.32
		M	mean velocity (0.96), log (0.83), total woody debris (0.86), boulder (0.90)	CRCB = -0.69 + 73.40 (mean velocity)	0.91
		L	total woody debris (0.90), bank root (0.97), pebble (-0.89)	CRCB = 1.08 - 0.034 (bank root)	0.92
	Green sunfish	H	silt (-0.69), gravel (0.86)	GRSF = -0.12 + 0.05 (gravel)	0.70
		M	disturbance (0.96), silt (0.81)	GRSF = -0.16 + 0.048 (disturbance)	0.91
		L	gravel (0.97), pebble (0.83)	GRSF = -0.29 + 0.036 (gravel)	0.93
	Fathead minnow	H	total woody debris (0.76), log complex (0.74)	FHMW = -0.098 + 0.001 (total woody debris)	0.51
		M	mean velocity (0.75), cobble (-0.76)	FHMW = 1.41 - 0.079 (cobble)	0.47
	Black bullhead	M	disturbance (0.86)	BLBH = 0.00056 + 0.0014 (disturbance)	0.69
		L	disturbance (0.98), silt (0.87)	BLBH = -0.026 + 0.0031 (disturbance)	0.96
	Largemouth bass	M	disturbance (0.92), silt (0.79)	LMB = -0.20 + 0.022 (disturbance)	0.83
		L	silt (0.88)	LMB = -0.040 + 0.004 (silt)	0.70
	Bluntnose minnow	M	disturbance (0.93), silt (0.79)	BLTM = -0.31 + 0.37 (disturbance)	0.83
		L	boulder (0.82), mean width (0.93)	BLTM = -8.21 + 1.62 (mean width) + 0.23 (boulder)	0.90
	Bluegill	M	disturbance (0.94), aquatic vegetation (0.73)	BLG = -0.076 + 0.0092 (disturbance)	0.87
	White sucker	L	mean velocity (0.97)	WHSK = -0.066 + 5.68 (mean velocity)	0.92

Table 8. Continued.

	Redfin shiner	L	disturbance (-0.84), silt (-0.92), rootwad (-0.86), bank root (0.84), log complex (-0.81), log (-0.80), pebble (0.82), mean width (0.81)	RFNS = 0.71 - 0.009 (silt)	0.79
	Yellow bullhead	L	disturbance (0.88), silt (0.92)	YLBH = -0.014 + 0.0011 (silt)	0.81
	Suckermouth minnow	L	mean velocity (0.93), gravel (-0.83)	SMMW = 0.49 + 8.12 (mean velocity) - 0.024 (gravel)	0.90
Riffle					
	Creek chub	H	total woody debris (0.88), log complex (0.75)	CRCB = 0.069 + 0.00068 (total woody debris)	0.72
		M	gravel (0.83), cobble (0.84), total woody debris (-0.91), canopy cover (-0.75), mean depth (-0.74)	CRCB = 0.57 - 0.0021 (total woody debris)	0.79
		L	gravel (0.97), cobble (0.88)	CRCB = 0.031 + 0.019 (gravel)	0.94
	Orangethroat darter	H	gravel (0.78), disturbance (-0.95), mean depth (0.95), mean width (0.85), mean velocity (0.95)	OTD = 0.21 - 0.0039 (disturbance)	0.88
		M	gravel (0.89), log complex (0.93)	OTD = 0.066 + 0.00095 (log complex)	0.84
	Central stoneroller	L	boulder (0.91)	CSTR = -1.63 + 0.58 (boulder)	0.77
	Slender madtom	L	gravel (-0.85), cobble (0.81)	SLMT = 1.79 - 0.096 (gravel)	0.64

of the variation in C/f of white suckers and mean width explained 84% of the variation in C/f of bluntnose minnows at lower reaches.

In riffle macrohabitats, 71% of all significant relationships were correlated with percent gravel (Table 8). For example, percent gravel was positively correlated with C/f of creek chubs and orangethroat darters in both mid and lower reaches. Catch per unit of slender madtoms was negatively correlated with percent gravel, but was positively correlated with larger substrate (i.e., cobble). Area of total woody debris explained 72% - 79% of the variation in C/f of creek chubs in headwater and mid reaches, but was not a significant variable for other species. Percent disturbance explained 88% of the variation in C/f of orangethroat darters at headwater reaches.

Many of the individual species relations help explain the observed trends in C/f of trophic guilds. For example, creek chubs were the dominant generalized-insectivore in mid-reach pools; consequently, C/f of creek chubs and generalized-insectivores were correlated with total woody debris and mean velocity (Tables 7 and 8). Percent disturbance was significantly correlated with C/f of omnivores, bluntnose minnows, and black bullheads in mid reaches where bluntnose minnows and black bullheads were the most common omnivores. However, increased C/f of omnivores and tolerant species with high percent disturbance or percent silt was also the result of species additions (i.e., yellow bullhead, golden shiner, mosquitofish, common carp). In mid-reach pools, the insectivore-piscivore guild was primarily comprised of green sunfish, largemouth bass, and bluegills. Whereas, in lower reaches, the insectivore-piscivore guild also included channel catfish, orangespotted sunfish, walleye, white crappie, and various sunfish

hybrids; thus, single-species relations in lower reaches may not reflect trends observed in trophic guilds. In riffle macrohabitats, physicochemical variables correlated with C/f of orangethroat darters were the same as those correlated with C/f of benthic-insectivore (Tables 7 and 8)–indicating the dominance of orangethroat darters in the benthic-insectivore guild.

Age and growth.–Age estimation and growth analysis were conducted on 1,071 central stonerollers, 883 creek chubs, 728 red shiners, and 625 green sunfish. Mean back-calculated length at age was similar among reaches for all species (Figure 11). However, mean back-calculated length at age 5 for green sunfish was significantly higher in headwater reaches followed by mid and lower reaches ($F = 32.10$, $df = 2, 5$, $P = 0.001$).

Because fish used in age and growth analysis were not collected independent of macrohabitat (i.e., pools and riffles), physicochemical habitat relations were determined from the macrohabitat where C/f for the species was highest (i.e., pools). Riparian area variables (i.e., canopy cover, bank root, rootwad, total woody debris, log, log complex) explained 64% - 89% of the variation in growth (Table 9). For example, area of log complex explained 71% of the variation in mean back-calculated length at age 1 of central stonerollers at headwater reaches and variation in mean back-calculated length at age 1 of creek chubs was best explained (89%) by area of rootwad at mid reaches. Substrate type was also significantly correlated with growth, where large substrate was correlated with increased growth. For example, mean back-calculated length at age 1 of creek chubs was negatively correlated with percent silt, but positively correlated with

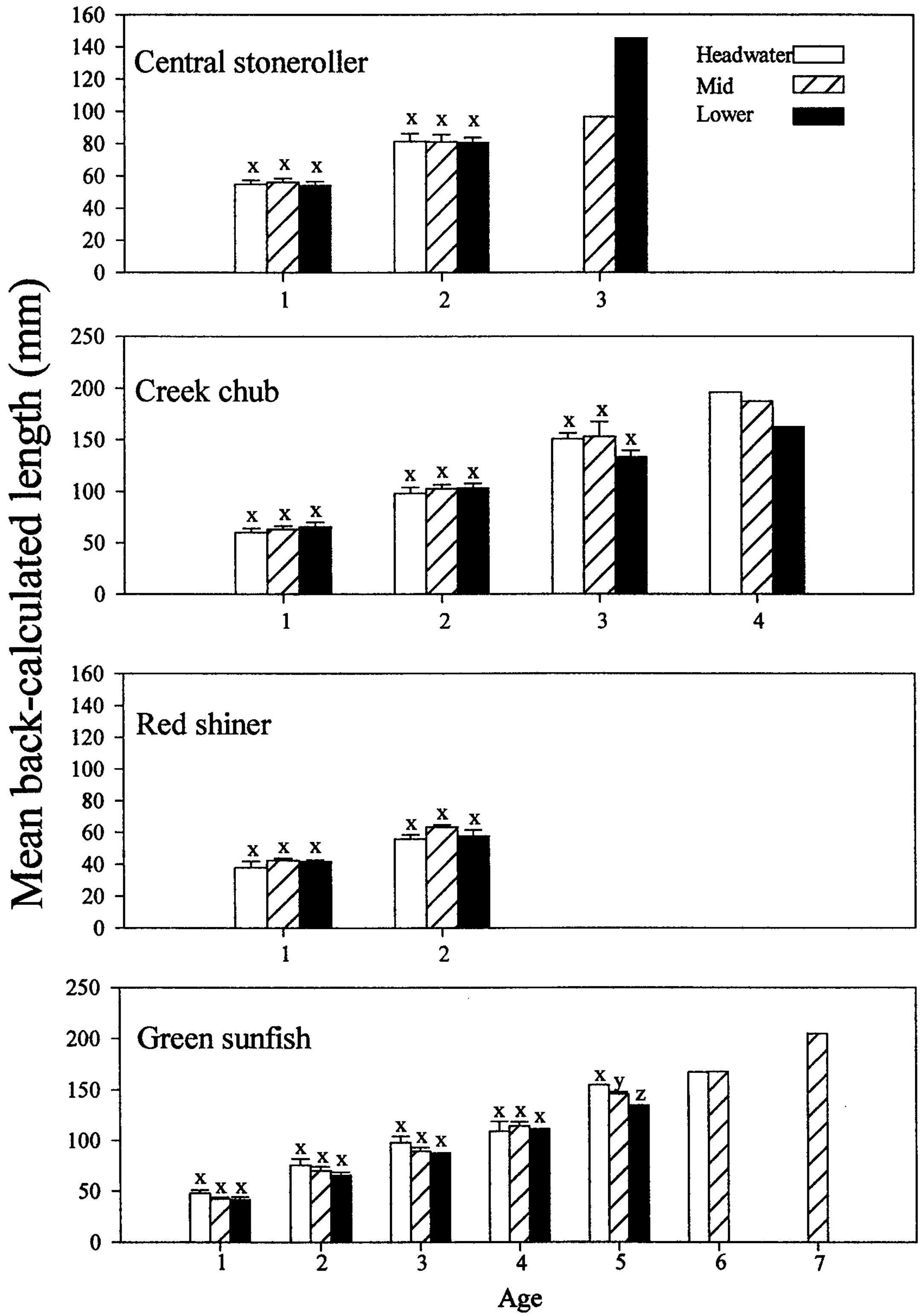

Figure 11. Mean back-calculated length at age for central stonerollers, creek chubs, red shiners, and green sunfish by reach (headwater, mid, lower) from streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter designates no significant difference ($P > 0.10$).

Table 9. Mean back-calculated length (BC) at age and significantly correlated variables ($P \leq 0.10$) by reach (H=headwater, M=mid, L=lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Equation is the best relationship determined by multiple regression analysis.

Species	Reach	Correlated variables (correlation coefficient)	Equation	r^2 or R^2
Central stoneroller BC1	H	log complex (0.88), phosphorous (0.77)	CSTR BC1 = 46.50 + 0.021 (log complex)	0.71
Creek chub BC1	H	aquatic vegetation (0.79), mean width (0.92), gravel (0.74), mean depth (0.86)	CRCB BC1 = 24.72 + 9.83 (mean width)	0.82
	M	canopy cover (0.92), bank root (0.89), rootwad (0.95), total woody debris (0.88)	CRCB BC1 = 56.79 + 0.22 (rootwad)	0.89
	L	bank root (0.93), pebble (0.87), log complex (-0.85), silt (-0.85)	CRCB BC1 = 57.98 + 0.077 (bank root)	0.80
Creek chub BC2	H	rootwad (-0.85)	CRCB BC2 = 121.10 - 0.21 (rootwad)	0.64
	M	canopy cover (0.97), rootwad (0.88), total woody debris (0.90), pebble (0.82), aquatic vegetation (-0.86)	CRCB BC2 = 83.80 + 0.56 (canopy cover)	0.93
	L	bank root (0.86), rootwad (0.94), pebble (0.82), gravel (0.86)	CRCB BC2 = 95.30 + 0.25 (rootwad)	0.86
Green sunfish BC1	M	canopy cover (0.74), pebble (0.74), aquatic vegetation (-0.88), mean width (-0.84), boulder (0.78), mean velocity (0.78)	GSF BC1 = 50.72 - 0.00056 (aquatic vegetation) - 1.44 (mean width)	0.86
Green sunfish BC2	M	mean depth (-0.76)	GSF BC2 = 119.77 - 160.59 (mean depth)	0.47
Green sunfish BC3	M	log (0.89)	GSF BC3 = 82.32 + 0.33 (log)	0.74
	L	canopy cover (-0.87)	GSF BC3 = 118.02 - 0.39 (canopy cover)	0.70
Red shiner BC1	L	mean width (-0.88)	RED BC1 = 43.96 - 0.84 (mean width)	0.69

percent pebble (Table 9). Biotic interactions influenced growth in lower reaches. Growth of central stonerollers, creek chubs, red shiners, and green sunfish was negatively correlated with C/f of each species in pool macrohabitats (r = -0.81 to -0.92, P = 0.02 to 0.09).

Most cyprinids are short lived and rarely live past age 2 (Pflieger 1997). Consequently, 88% of the sampled central stonerollers, creek chubs, and red shiners were < age 2 (Figure 12). Age structure was similar among reaches for central stoneroller, creek chub, and green sunfish populations. However, the proportion of age-1 red shiners was significantly greater in mid and lower reaches (F = 5.59, df = 2, 9, P = 0.02). Conversely, the proportion of age-2 red shiners was significantly greater in headwater reaches (F = 5.56, df = 2, 9, P = 0.02).

The majority of the relationships among physicochemical variables and age structure were weakly correlated (r < 0.60) and non-significant (P > 0.10). However, percent boulder substrate in headwater reaches was negatively correlated to the proportion of age-0 creek chubs (r = -0.99; P = 0.0001) and percent canopy cover was negatively correlated with the proportion of age-0 central stonerollers (r = -0.91, P = 0.01). The proportion of age-0 central stonerollers in mid-reach sites was negatively correlated with mean depth (r = -0.85, P = 0.06). In lower reaches, the proportion of age-0 central stonerollers was negatively correlated with percent boulder substrate (r = -0.86, P = 0.06) and the proportion of age-0 creek chubs was positively correlated with percent silt (r = 0.90, P = 0.04).

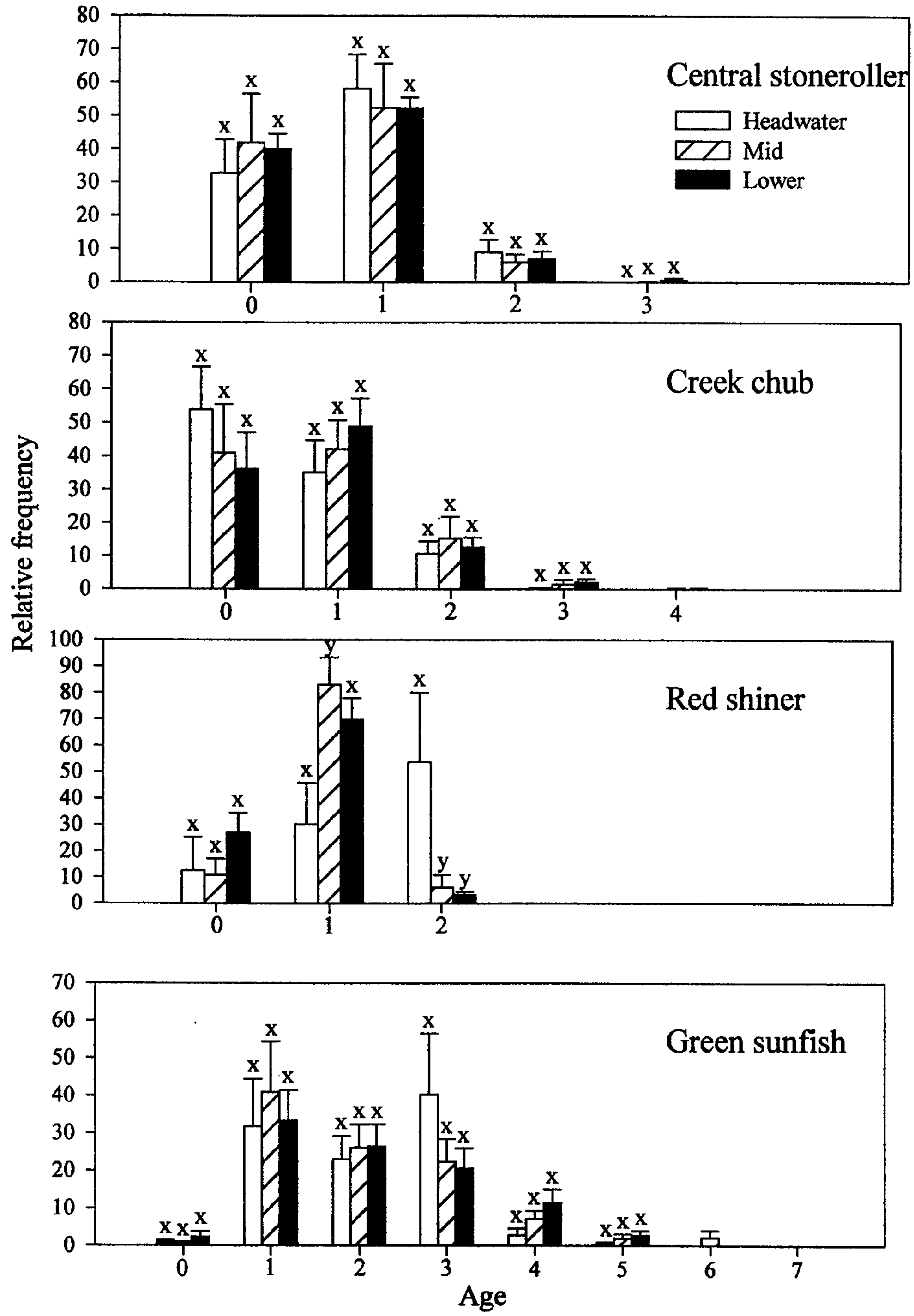

Figure 12. Age structure histograms for central stonerollers, creek chubs, red shiners, and green sunfish by reach (headwater, mid, lower) for streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Bars represent one standard error. Reaches with the same letter designates no significant difference ($P > 0.10$).

Discussion

Numerous researchers have documented a response in fish assemblage structure and function with increasing habitat area, volume, and complexity (Sheldon 1968; Gorman and Karr 1978; Schlosser 1982b). For example, Sheldon (1968) found that species richness in a New York stream increased longitudinally and likely resulted from increased habitat volume. Similarly, Gorman and Karr (1978) found that species diversity was related to increased habitat diversity in Indiana and Panama streams. I found that physicochemical habitat and fish community characteristics varied among reaches, and patterns in longitudinal variation of fish assemblage characteristics are similar to those documented for other ecosystems. Species richness, species diversity, and trophic guild diversity increased longitudinally and was likely a function of habitat area and volume.

Fish community characteristics in streams also vary by macrohabitat. Angermeier and Schlosser (1989) found that species richness and fish densities were greater in pool macrohabitats (versus riffles) in Minnesota and Panama streams due to increased habitat volume. In addition, the authors suggested that prey availability in riffle macrohabitats is generally limited to periphyton, aquatic macroinvertebrates, and other fishes; whereas, additional prey such as terrestrial invertebrates and plant material are often available to pool species. I found similar macrohabitat-specific patterns in tallgrass-prairie streams where species richness, species diversity, trophic guild diversity, and abundance of fishes were greatest in pool macrohabitats. Similar to Sheldon (1968), the observed longitudinal and macrohabitat patterns in abundance of fishes in trophic guilds, tolerance

categories, and species were usually the result of species additions rather than replacement.

These data suggest that longitudinal patterns in instream habitat and fish communities in streams on Fort Riley are similar to other lotic systems. However, within reach (i.e., headwater, mid, lower) relations are not well understood–especially in tallgrass-prairie ecosystems. With the effects of longitudinal variation removed, many of the relationships within reaches were related to landscape-level conditions such as disturbance in the watershed from military activity and riparian canopy cover.

Disturbance within the watershed from military activity was related to an increase in silt in headwater reaches; however, silt was rarely correlated with fish community characteristics. Gravel appeared to be important for fishes in headwater reaches. Headwater reaches that had a lot of silt and little gravel or other large substrate generally contained few species; however, a slight improvement in habitat heterogeneity (e.g., gravel) was related to the addition of new species–albeit tolerant species and trophic generalists. Disturbance within mid-reach watersheds was important in determining the structure and function of fish communities. Species diversity increased with disturbance from military training, but species diversity does not reflect fish community composition. Kushlan (1976) found that fish species diversity in Everglade marshes increased in response to enhanced water-level stability. Although fish species diversity increased, the fish community shifted from an assemblage of small omnivores to large piscivorous species. On Fort Riley, increased species diversity was the result of the addition of tolerant species and trophic generalists (e.g., yellow bullhead, golden shiner,

mosquitofish, common carp). Disturbance in the watershed did not appear to directly influence lower reaches. Most significant relationships in lower reaches were related to stream morphology (e.g., mean width, mean depth) or hydrology (e.g., mean velocity)–indicating that even on a relatively small-scale, species-area relationships may be important in lower reaches (Angermeier and Schlosser 1989).

One of the impacts of military training at the landscape-level is disturbance to the soil and vegetation. Several studies have documented deleterious changes in vegetation abundance and species composition resulting from military tracked-vehicle disturbance (Severinghaus and Goran 1981; McKeran 1984; Wilson 1988). Although few scientists have studied the direct impact to soil and subsequent erosion from training maneuvers, Wilson (1988) found that the amount of bare ground increased significantly with high tracked-vehicle activity. Similar results have been documented on Fort Riley (B. Rubenstein, Kansas State University, personal communication). The potential for surface erosion is directly related to the amount of bare soil exposed to rainfall and surface-water runoff (Chamberlin et al. 1991). If the infiltration capacity of the soil is reduced through compaction or filling of pores by fine sediments, water runs over (rather than through) the soil (Lull 1959; Chamberlin et al. 1991), causing higher peak flows and increased sediment transport (Harr 1979). The influence of soil disturbance on streams by large-machinery is well documented for forested salmonid streams (Greacen and Sands 1980; Chamberlin et al. 1991). For example, Reid and Dunne (1984) found that logging roads increased sediment input by 40% when exposed to intense traffic. Furthermore, the influence of soil disturbance is magnified in steep terrain (Smith and

Wass 1980). In the Flint Hills, row-crop agriculture is minimal due to the steep slopes and rocky soils (Metcalf 1966; Lauver 1994). The majority of the uplands in the Flint Hills region are used for livestock grazing. Thus, many Flint Hills streams have low amounts of silt. Conversely, military training on Fort Riley is usually conducted in the upland areas which disturbs the soil and vegetation community.

Despite well-developed riparian zones on Fort Riley, it appears that these areas are not "filtering" runoff from disturbed areas. Rabeni and Smale (1995) argued that although slope, soil type, vegetation type, and geology are all important components of riparian areas, continuity may be the most critical. They stated that riparian vegetation must prevent the formation of rills, gullies, or other pathways which provide access of silt to streams. As stated previously, many streams on Fort Riley are traversed by maintained and unimproved tank-trails. These crossings likely provide avenues for silt to enter streams and link landscape-level disturbance with instream processes. Although this study was not designed to specifically address the locality of sediment input, it does provide baseline information for further study.

Although riparian areas did not adequately reduce siltation in highly disturbed watersheds, these areas are an integral component for stream ecosystem function in the Flint Hills. As riparian canopy cover increased, fluctuations in daily temperature and overall temperature decreased. This relationship may be especially important to temperature-sensitive species. In addition, riparian vegetation influenced woody debris input and provided instream cover for fishes. Fallen woody debris enhances the retention of organic matter and inorganic sediments by forming debris dams (Speaker et al. 1984).

Debris dams become sources of nutrients and provide substrate for aquatic organisms (Triska et al. 1983; Benke et al. 1984) which decompose wood and form a major component of trophic food webs in stream ecosystems. Furthermore, Nilsen and Larimore (1973), Angermeier and Karr (1984), and Benke et al. (1984) suggested instream woody debris is especially important in habitats with unstable or unproductive substrate. Riparian vegetation is also important for stream ecosystems because it enhances stream-bank stability, allochthonous energy input, and provides cover for fishes (Platts 1983; Moring et al. 1985; Cummins et al. 1989). In addition, over-story vegetation filters and absorbs solar radiation, thus affecting primary production and stream temperatures (Lyford and Gregory 1975). Few studies have documented the effects of canopy cover on prairie streams.

Information on the relationships between growth and physicochemical habitat in small, lotic ecosystems is scarce. Those studies which have been conducted have focused on sport fishes (e.g., Putnam et al. 1995) or on the abundance of juveniles, rather than incremental growth (e.g., Schlosser 1985). Growth of many species was related to either woody debris or substrate particle size. Creek chubs are a generalized-insectivore which feed on a variety of aquatic macroinvertebrates (Dinsmore 1962; Pflieger 1997). Thus, the growth of creek chubs may reflect the importance of woody debris as a source of invertebrate prey. Similarly, increased growth of central stonerollers in headwater reaches was correlated to the amount of log-complex habitat. Central stonerollers are herbivore-detritivores and feed primarily on attached periphyton (Kraatz 1923; Pflieger 1997). Woody debris may serve as a surrogate substrate for primary production because

of the lack of suitable substrate for periphyton attachment in headwater streams on Fort Riley. Growth of green sunfish decreased with larger substrate during early life stages in mid reaches; however, growth of older fish was directly related to the amount of woody debris. These data likely represent the ontogenetic shift in diet from macroinvertebrates to fishes (Pflieger 1997). Woody debris may attract prey fish, but may also serve as ambush areas–especially in the absence of aquatic vegetation.

The proportion of age-0 fish was generally greatest in areas with little overhead canopy cover, shallow depths, and smaller substrate particle size. For example, many sites (primarily in headwater reaches) that had low amounts of gravel and other rocky substrates generally had a high proportion of age-0 creek chubs and central stonerollers. The presence of age-0 fish in habitat unsuitable for spawning adults may be a function of age-0 fish acting as colonizers. As fish mature it is possible that many move to more suitable habitats (e.g., higher velocity areas for larger central stonerollers, larger pools for creek chubs). It is likely that fish remain in these areas and high mortality limits the abundance of adults. Schlosser (1982b) found that shallow, temporally variable areas in an Illinois stream were dominated by young age groups, suggesting the importance of environmental stability.

Numerous authors have alluded to the influence of density-dependent competition on growth of fishes; however, most studies have been conducted in lentic systems (LeCren 1958; Grice 1959) or large rivers (Legget 1977; Bayley 1988), rather than small, lotic ecosystems. This is likely due to the paucity of research regarding incremental growth rates of small stream fishes. In streams on Fort Riley, growth of central

stonerollers, creek chubs, red shiners, and green sunfish was negatively correlated with their abundance in lower reaches. Despite the rarity of biotic relationships in most reaches, the apparent density-dependent regulation of growth further suggests the importance of deterministic processes in lower stream reaches (Grossman et al. 1982; Herbold 1984; Rahel et al. 1984; Yant et al. 1984; Schlosser 1985). Although this hypothesis has yet to be tested in tallgrass-prairie streams, it does provide a framework for future community and species-specific research in prairie ecosystems.

The results of this study suggest the importance of landscape-level disturbance on physicochemical habitat and fish community characteristics, and have implications beyond military training activities. Urban development, timber-harvest practices, mining, and agriculture have been shown to increase the amount of sediment in stream ecosystems by exposing and compacting the soil (Waters 1995). I surmise that military training activities influence sedimentation of streams in a similar manner. This study also suggests the importance of riparian continuity. Although riparian areas filter sediment and decrease surface runoff, I found that improved and unimproved stream crossings disrupt riparian continuity and likely provide access of silt to streams. Thus, riparian continuity may be an integral component of stream ecosystems that is often overlooked in natural resource management and land-use planning.

Research Needs

1. Determine point and non-point sources of sediment input and document temporal variation in sediment transport.
2. Determine the influence of improved and unimproved stream crossings and the proximity of training to streams on sedimentation processes. Examine the use of mitigation techniques (e.g., runoff deflectors along roadsides) and their role in decreasing sediment input to streams. Document the effects of discontinuous riparian vegetation on sedimentation processes.
3. Document spatial and temporal changes in physicochemical habitat in streams associated with small impoundments. Determine the influence of small impoundments on recolonization of streams and their influence on fish and invertebrate communities.
4. Assess the role of large water bodies (i.e., Milford Reservoir, Kansas River) on recolonization and fish community characteristics in streams.
5. Identify spatial and temporal variation in aquatic invertebrate (e.g., aquatic macroinvertebrates, mollusks) species composition and abundance. Assess the influence of sediment input on habitat availability and aquatic invertebrate communities.
6. Identify the factors that determine the presence or absence of Topeka shiners. Determine the influence of predators (e.g., largemouth bass, green sunfish) and competitors (e.g., red shiners) on the abundance of Topeka shiners.
7. Determine the influence of largemouth bass and bluegills on fish communities.

Document food habitats, age structure, growth, and mortality of largemouth bass and bluegills in streams.

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Appendix A. Mean **physical habitat** and **cover** characteristics for **pool** macrohabitats in streams on Fort Riley Military Reservation sampled during June and July 1997, 1998. Number in parenthesis represents standard error.

	Physicochemical variables			
Reach–stream	Depth (m)	Width (m)	Velocity (m/s)	Canopy cover (%)
Headwater				
Dry	0.37 (0.008)	4.7 (0.1)	0.001 (0.0003)	37.4 (31.5)
Farnum	0.23 (0.1)	2.7 (1.3)	0.001 (0.0002)	74.9 (8.4)
Forsyth	0.27 (0.002)	4.1 (0.5)	0.05 (0.01)	76.7 (3.4)
Fourmile	0.19 (0.02)	2.7 (0.05)	0.02 (0.004)	99.8 (0.1)
Little Arkansas	0.19 ([a])	2.8 ([a])	0.005 ([a])	92.4 ([a])
Rush	0.24 (0.01)	3.8 (0.5)	0.01 (0.003)	95.9 (0.03)
Threemile	0.22 (0.06)	3.1 (0.3)	0.003 (0.0004)	93.0 (6.1)
Wind	0.29 (0.08)	5.1 (1.9)	0.006 (0.001)	62.5 (13.6)
Mid				
Farnum	0.29 (0.02)	5.4 (0.2)	0.007 (0.002)	62.8 (9.1)
Forsyth	0.32 (0.06)	4.2 (0.1)	0.04 (0.004)	94.0 (4.5)
Honey	0.22 ([a])	4.0 ([a])	0.01 ([a])	74.9 ([a])
Little Arkansas	0.34 (0.02)	4.1 (0.3)	0.02 (0.005)	98.0 (15.0)
Timber	0.36 (0.01)	6.1 (0.2)	0.02 (0.004)	87.8 (6.2)
Wind	0.33 (0.04)	5.9 (0.07)	0.007 (0.002)	58.6 (13.1)
Lower				
Madison	0.28 (0.04)	4.5 (0.8)	0.09 (0.03)	63.1 (8.2)
Sevenmile	0.28 (0.06)	5.2 (0.3)	0.05 (0.005)	88.0 (2.1)
Threemile	0.44 (0.07)	6.5 (0.9)	0.01 (0.005)	78.3 (4.2)
Wildcat	0.44 (0.08)	8.8 (0.6)	0.05 (0.008)	80.6 (4.3)
Wind	0.31 (0.03)	5.2 (0.5)	0.008 (0.002)	71.6 (8.6)

Appendix A. Continued (see page 69 for heading).

	Physicochemical variables						
Reach–stream	Bedrock (%)	Boulder (%)	Clay (%)	Cobble (%)	Gravel (%)	Pebble (%)	Silt (%)
Headwater							
Dry	0 (0)	0 (0)	41.4 (0.5)	0 (0)	0 (0)	0 (0)	58.6 (0.2)
Farnum	0 (0)	0 (0)	6.1 (6.1)	3.9 (3.9)	2.3 (2.3)	0.3 (0.3)	87.3 (4.1)
Forsyth	0 (0)	7.3 (7.3)	25.2 (10.9)	14.8 (0.6)	13.8 (3.9)	6.9 (0.9)	29.9 (3.8)
Fourmile	0 (0)	6.2 (3.3)	14.2 (3.8)	9.4 (9.4)	2.5 (2.5)	3.1 (3.1)	64.5 (8.0)
Little Arkansas	0 ([a])	0 ([a])	13.9 ([a])	0 ([a])	8.3 ([a])	0.3 ([a])	77.6 ([a])
Rush	0 (0)	0.6 (0.6)	0.6 (0.6)	4.8 (4.8)	10.6 (5.6)	10.4 (3.2)	73.1 (2.8)
Threemile	0 (0)	5.2 (0.5)	0 (0)	2.8 (2.8)	14.1 (6.3)	6.7 (0.4)	71.6 (4.2)
Wind	0 (0)	0.4 (0.4)	0 (0)	5.0 (2.0)	22.2 (11.2)	11.0 (9.7)	59.1 (21.1)
Mid							
Farnum	0 (0)	0 (0)	1.6 (1.3)	6.5 (0.9)	15.3 (0.5)	5.9 (2.5)	70.7 (1.6)
Forsyth	0 (0)	18.6 (18.6)	5.9 (0.6)	7.7 (0.6)	12.6 (3.1)	13.9 (0.6)	41.1 (22.3)
Honey	5.7 ([a])	7.9 ([a])	7.9 ([a])	13.3 ([a])	40.1 ([a])	17.5 ([a])	7.5 ([a])
Little Arkansas	0.3 (0.3)	2.3 (2.3)	4.9 (2.2)	9.3 (1.6)	32.5 (3.9)	20.4 (13.0)	30.4 (2.6)
Timber	0 (0)	3.4 (1.9)	5.9 (1.8)	7.6 (2.3)	33.2 (3.5)	17.9 (6.9)	31.9 (6.1)
Wind	3.2 (3.2)	0 (0)	12.7 (7.3)	17.2 (9.4)	13.1 (6.4)	5.4 (1.2)	48.4 (8.4)
Lower							
Madison	0 (0)	0 (0)	7.3 (3.5)	0.2 (0.2)	12.0 (6.8)	1.3 (0.9)	79.2 (10.4)
Sevenmile	22.7 (13.3)	9.1 (3.8)	5.4 (4.9)	10.9 (5.3)	9.6 (4.2)	4.0 (2.5)	38.1 (20.8)
Threemile	0 (0)	0.1 (0.1)	21.0 (13.0)	1.7 (0.8)	20.7 (7.4)	9.0 (5.1)	47.4 (13.2)
Wildcat	11.6 (7.3)	13.6 (6.4)	8.6 (3.5)	14.1 (3.9)	22.1 (9.4)	25.5 (7.0)	4.5 (2.3)
Wind	2.0 (2.0)	3.6 (1.5)	3.5 (2.2)	26.7 (10.4)	20.4 (4.2)	30.5 (9.5)	13.3 (7.5)

Appendix A. Continued (see page 69 for heading).

	Physicochemical variables				
Reach–stream	Aquatic vegetation (m^2/ha)	Branch complex (m^2/ha)	Boulder (m^2/ha)	Bank root (m^2/ha)	Log (m^2/ha)
Headwater					
Dry	7447.2 (1.1)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	488.8 (488.8)	48.9 (48.9)	0 (0)	61.6 (61.6)	6.8 (6.8)
Forsyth	0 (0)	0 (0)	2.6 (2.6)	18.9 (18.9)	33.3 (31.3)
Fourmile	0 (0)	17.7 (17.7)	0 (0)	92.3 (51.0)	65.8 (52.1)
Little Arkansas	48.7 ([a])	44.9 ([a])	0 ([a])	7.5 ([a])	12.7 ([a])
Rush	0 (0)	0 (0)	0 (0)	44.7 (44.7)	11.1 (5.7)
Threemile	0 (0)	0 (0)	0 (0)	58.9 (58.9)	0 (0)
Wind	1340.1 (1340.1)	48.9 (36.9)	0 (0)	3.3 (3.3)	7.1 (1.7)
Mid					
Farnum	5838.5 (1941.9)	109.5 (13.7)	0 (0)	9.8 (9.8)	21.9 (11.9)
Forsyth	0 (0)	25.8 (25.8)	185.3 (185.3)	107.6 (107.6)	54.9 (49.9)
Honey	1820.4 ([a])	205.6 ([a])	0 ([a])	0 ([a])	0 ([a])
Little Arkansas	0 (0)	48.3 (7.9)	0 (0)	234.9 (150.5)	25.2 (18.2)
Timber	226.7 (226.7)	109.2 (104.6)	0 (0)	49.2 (33.9)	3.8 (3.4)
Wind	6126.2 (1373.8)	0 (0)	0 (0)	12.9 (12.9)	0 (0)
Lower					
Madison	1283.6 (1200.3)	8.5 (17.0)	0 (0)	2.3 (2.3)	36.7 (36.1)
Sevenmile	0 (0)	51.8 (35.0)	17.9 (17.9)	0 (0)	10.5 (7.5)
Threemile	193.9 (193.9)	165.9 (122.4)	0 (0)	1.1 (1.1)	26.3 (19.0)
Wildcat	0 (0)	1.9 (1.9)	0 (0)	23.7 (11.3)	6.2 (3.2)
Wind	139.0 (84.7)	49.3 (34.3)	0.5 (0.5)	25.1 (9.2)	10.4 (5.5)

Appendix A. Continued (see page 69 for heading).

	Physicochemical variables			
Reach–stream	Log complex (m^2/ha)	Root wad (m^2/ha)	Undercut bank (m^2/ha)	Total woody debris (m^2/ha)
Headwater				
Dry	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	7.3 (7.3)	0 (0)	240.1 (240.1)	124.6 (1.4)
Forsyth	643.9 (2.7)	185.9 (164.1)	5.0 (5.0)	882.0 (217.1)
Fourmile	259.1 (7.39)	120.6 (39.6)	0 (0)	555.6 (51.5)
Little Arkansas	864.7 ([a])	20.5 ([a])	6.2 ([a])	950.3 ([a])
Rush	398.7 (129.2)	75.3 (68.4)	0 (0)	529.9 (21.8)
Threemile	206.0 (168.6)	116.5 (116.5)	253.8 (253.8)	381.4 (226.2)
Wind	453.9 (419.9)	45.2 (20.1)	0 (0)	558.3 (364.5)
Mid				
Farnum	62.5 (62.5)	0 (0)	55.7 (55.7)	203.8 (46.6)
Forsyth	305.2 (176.3)	66.9 (20.5)	5.3 (5.3)	560.5 (72.3)
Honey	0 ([a])	0 ([a])	217.2 ([a])	205.6 ([a])
Little Arkansas	46.6 (46.6)	74.9 (52.7)	28.1 (28.1)	430.1 (40.9)
Timber	202.5 (79.7)	34.6 (34.6)	9.5 (4.0)	399.3 (119.3)
Wind	181.6 (84.9)	3.4 (3.4)	15.9 (15.9)	197.9 (75.4)
Lower				
Madison	501.9 (220.4)	2.6 (2.6)	5.0 (5.0)	552.1 (195.1)
Sevenmile	452.1 (213.0)	0 (0)	0 (0)	514.3 (207.5)
Threemile	408.9 (146.4)	10.4 (7.4)	4.9 (4.0)	612.6 (107.3)
Wildcat	248.8 (110.5)	18.4 (13.2)	0 (0)	298.9 (117.5)
Wind	184.4 (62.4)	42.4 (15.1)	32.4 (30.1)	311.6 (90.7)

[a] Only one sub-sample was sampled.

Appendix B. Mean **physical habitat** and **cover** characteristics for **riffle** macrohabitats in streams on Fort Riley Military Reservation sampled during June and July 1997, 1998. Number in parenthesis represents standard error.

	Physicochemical variables			
Reach–stream	Depth (m)	Width (m)	Velocity (m/s)	Canopy cover (%)
Headwater				
Dry[a]				
Farnum	0.02 ([b])	0.3 ([b])	0.02 ([b])	99.9 ([b])
Forsyth	0.08 (0.01)	2.9 (0.5)	0.24 (0.04)	80.9 (7.3)
Fourmile	0.04 (0.009)	2.1 (0.2)	0.11 (0.001)	99.5 (0.2)
Little Arkansas[a]				
Rush	0.03 (0.007)	1.4 (0.6)	0.05 (0.02)	97.1 (1.8)
Threemile	0.01 (0.0004)	1.1 (0.6)	0.08 (0.001)	93.9 (1.8)
Wind	0.02 ([b])	1.6 ([b])	0.07 ([b])	60.0 ([b])
Mid				
Farnum	0.03 (0.002)	1.9 (0.3)	0.04 (0.02)	65.1 (4.6)
Forsyth	0.06 (0.005)	3.2 (0.08)	0.18 (0.02)	91.4 (6.5)
Honey	0.06 ([c])	3.3 ([c])	0.11 ([c])	87.7 ([c])
Little Arkansas	0.05 (0.04)	1.2 (0.4)	0.09 (0.07)	92.5 (0.3)
Timber	0.06 (0.008)	2.6 (0.5)	0.22 (0.04)	89.9 (4.9)
Wind	0.02 (0.003)	1.6 (0.03)	0.09 (0.03)	61.5 (8.5)
Lower				
Madison	0.06 (0.004)	2.7 (1.2)	0.28 (0.07)	57.0 (26.7)
Sevenmile	0.10 0.02)	3.4 (0.5)	0.17 (0.007)	83.7 (2.9)
Threemile	0.07 (0.001)	2.3 (0.2)	0.26 (0.03)	85.3 (4.8)
Wildcat	0.08 (0.001)	4.8 (0.4)	0.27 (0.03)	77.8 (6.4)
Wind	0.04 (0.01)	2.2 (0.5)	0.10 (0.01)	73.4 (5.9)

Appendix B. Continued (see page 73 for heading).

	Physicochemical variables						
Reach–stream	Bedrock (%)	Boulder (%)	Clay (%)	Cobble (%)	Gravel (%)	Pebble (%)	Silt (%)
Headwater							
Dry[a]							
Farnum	0 ([b])	0 ([b])	23.7 ([b])	0 ([b])	0 ([b])	0 ([b])	76.3 ([b])
Forsyth	0 (0)	9.2 (7.9)	3.3 (3.3)	31.2 (11.7)	36.0 (5.2)	21.9 (4.8)	2.3 (2.3)
Fourmile	0 (0)	13.7 (9.4)	0 (0)	58.8 (5.4)	1.8 (1.8)	25.7 (2.2)	0 (0)
Little Arkansas[a]							
Rush	0 (0)	13.5 (13.5)	0 (0)	23.3 (23.3)	8.5 (8.5)	13.7 (8.3)	40.9 (36.7)
Threemile	0 (0)	2.2 (2.2)	0 (0)	20.3 (12.3)	16.7 (16.7)	22.6 (8.4)	38.2 (10.6)
Wind	0 ([b])	2.2 ([b])	0 ([b])	42.2 ([b])	2.2 ([b])	49.2 ([b])	4.2 ([b])
Mid							
Farnum	0 (0)	1.5 (1.5)	0 (0)	50.3 (15.1)	14.1 (0.9)	32.3 (15.1)	1.8 (0.4)
Forsyth	0 (0)	4.3 (3.4)	0.3 (0.3)	27.9 (4.9)	14.6 (3.4)	51.1 (9.8)	1.7 (1.7)
Honey	2.2 ([c])	5.8 ([c])	0 ([c])	30.5 ([c])	11.5 ([c])	49.9 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	13.0 (5.8)	13.6 (7.4)	73.3 (1.5)	0 (0)
Timber	0 (0)	0.9 (0.9)	0.7 (0.5)	29.4 (4.8)	18.7 (5.5)	49.7 (5.6)	0.6 (0.6)
Wind	0 (0)	1.1 (1.1)	0 (0)	66.9 (16.9)	6.0 (6.0)	25.9 (24.1)	0 (0)
Lower							
Madison	0 (0)	10.5 (10.5)	4.8 (4.8)	36.5 (17.0)	16.9 (2.3)	25.9 (25.9)	5.4 (5.4)
Sevenmile	2.0 (2.0)	6.2 (2.4)	0 (0)	45.1 (19.4)	16.3 (10.2)	19.9 (10.1)	10.6 (10.6)
Threemile	0 (0)	4.3 (4.3)	1.4 (1.4)	36.4 (11.4)	19.0 (9.7)	38.8 (6.0)	0 (0)
Wildcat	6.2 (6.2)	3.7 (2.0)	0.5 (0.5)	56.9 (8.1)	1.1 (0.6)	31.5 (11.9)	0 (0)
Wind	0 (0)	4.6 (3.0)	0 (0)	48.3 (11.9)	9.2 (3.6)	37.8 (13.3)	0 (0)

Appendix B. Continued (see page 73 for heading).

	Physicochemical variables				
Reach–stream	Aquatic vegetation (m^2/ha)	Branch complex (m^2/ha)	Boulder (m^2/ha)	Bank root (m^2/ha)	Log (m^2/ha)
Headwater					
Dry[a]					
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	133.9 (133.9)	21.6 (21.6)	7.9 (7.9)	78.3 (78.3)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	26.9 (26.9)
Little Arkansas[a]					
Rush	0 (0)	23.8 (23.8)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid					
Farnum	1178.8 (1178.8)	0 (0)	0 (0)	0 (0)	199.8 (199.8)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	6.1 (6.1)
Honey	3.2 ([c])	71.8 ([c])	0 ([c])	98.8 ([c])	0 ([c])
Little Arkansas	0 (0)	126.5 (126.5)	0 (0)	0 (0)	0 (0)
Timber	109.2 (109.2)	0 (0)	0 (0)	0 (0)	5.6 (5.6)
Wind	181.8 (181.8)	0 (0)	0 (0)	0 (0)	0 (0)
Lower					
Madison	0 (0)	0 (0)	0 (0)	0 (0)	13.2 (13.2)
Sevenmile	0 (0)	0 (0)	0 (0)	0 (0)	42.0 (42.0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	6.3 (6.3)
Wildcat	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	9.3 (9.3)

Appendix B. Continued (see page 73 for heading).

	Physicochemical variables			
Reach–stream	Log complex (m^2/ha)	Root wad (m^2/ha)	Undercut bank (m^2/ha)	Total woody debris (m^2/ha)
Headwater				
Dry[a]				
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	98.5 (98.5)	0 (0)	0 (0)	318.6 (161.9)
Fourmile	168.7 (168.7)	0 (0)	0 (0)	195.5 (195.5)
Little Arkansas[a]				
Rush	905.2 (905.2)	0 (0)	0 (0)	928.8 (881.3)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid				
Farnum	68.8 (68.8)	0 (0)	0 (0)	268.6 (268.6)
Forsyth	187.0 (26.1)	0 (0)	0 (0)	193.2 (20.0)
Honey	0 ([c])	59.7 ([c])	20.5 ([c])	230.2 ([c])
Little Arkansas	118.6 (118.6)	0 (0)	0 (0)	245.2 (245.2)
Timber	296.2 (145.8)	0 (0)	0 (0)	301.9 (146.6)
Wind	0 (0)	0 (0)	0 (0)	0 (0)
Lower				
Madison	0 (0)	0 (0)	0 (0)	13.2 (13.2)
Sevenmile	951.9 (876.7)	0 (0)	0 (0)	993.9 (918.7)
Threemile	204.0 (103.7)	0 (0)	0 (0)	210.3 (106.0)
Wildcat	130.0 (130.0)	0 (0)	0 (0)	130.1 (130.1)
Wind	76.2 (50.9)	0 (0)	0 (0)	85.5 (52.6)

[a] Riffle macrohabitats were absent.
[b] Only one sub-sample contained riffle macrohabitats.
[c] Only one sub-sample was sampled.

Appendix C. Fish **community indices** and catch per unit effort (fish/min of **electrofishing**) by **trophic guild, tolerance category** and **species in pool** macrohabitats from streams on Fort Riley Military Reservation sampled during June and July 1997, 1998. Number in parenthesis represent standard error.

	Community index			Trophic guild			
Reach–stream	Species richness (S)	Species diversity (H_S')	Trophic guild diversity (H_T')	Benthic-insectivore (fish/min)	Generalized-insectivore (fish/min)	Insectivore-piscivore (fish/min)	Omnivore (fish/min)
Headwater							
Dry	0.5 (0.5)	0 ([a])	0 ([a])	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0.7 (0.7)	1.22 ([a])	1.22 ([a])	0 (0)	0.02 (0.02)	0.04 (0.04)	0.10 (0.1)
Forsyth	3.6 (1.6)	0.75 (0.3)	0.73 (0.2)	0.66 (0.66)	1.25 (0.3)	0.11 (0.07)	1.08 (1.01)
Fourmile	3.6 (0.4)	1.00 (0.17)	0.59 (0.08)	0.50 (0.3)	1.72 (0.1)	0 (0)	0.09 (0.02)
Little Arkansas	2.7 ([b])	1.00 ([b])	0.79 ([b])	0 ([b])	0.14 ([b])	0.27 ([b])	1.14 ([b])
Rush	0.9 (0.2)	0.67 (0.3)	0.67 (0.3)	0.10 (0.1)	1.52 (1.4)	0.05 (0.05)	0.01 (0.01)
Threemile	2.3 (0.3)	0.58 (0.16)	0.53 (0.1)	0.05 (0.03)	0.21 (0.2)	0.34 (0.03)	0.33 (0.1)
Wind	6.7 (1.9)	1.34 (0.03)	0.91 (0.007)	0.88 (0.01)	1.70 (1.04)	0.78 (0.1)	1.89 (0.3)
Mid							
Farnum	7.7 (0.3)	1.53 (0.08)	1.03 (0.04)	1.04 (0.11)	0.13 (0.05)	1.79 (0.1)	1.45 (0.5)
Forsyth	4.2 (0.02)	0.93 (0.1)	0.81 (0.03)	1.07 (0.4)	1.34 (0.4)	0.05 (0.05)	0.28 (0.12)
Honey	3.2 ([b])	0.72 ([b])	0.72 ([b])	0.80 ([b])	0.12 ([b])	0.009 ([b])	0.23 ([b])
Little Arkansas	6.8 (2.8)	1.39 (0.4)	0.84 (0.01)	0.68 (0.3)	0.46 (0.2)	0.33 (0.2)	0.33 (0.02)
Timber	6.8 (0.9)	1.41 (0.06)	0.94 (0.07)	2.37 (0.9)	1.22 (0.4)	0.43 (0.1)	0.73 (0.4)
Wind	4.5 (0.5)	1.23 (0.02)	0.36 (0.36)	0.20 (0.2)	0.28 (0.2)	0.55 (0.2)	0.22 (0.2)
Lower							
Madison	9.4 (1.4)	1.52 (0.04)	1.08 (0.08)	2.29 (1.08)	2.79 (0.9)	0.67 (0.3)	0.6 (0.2)
Sevenmile	11.8 (1.2)	1.85 (0.05)	1.06 (0.1)	1.71 (0.9)	2.34 (0.9)	0.17 (0.09)	1.14 (0.4)
Threemile	11.3 (2.9)	1.61 (0.2)	0.80 (0.19)	1.36 (0.8)	2.83 (1.1)	0.98 (0.4)	1.67 (0.6)
Wildcat	14.2 (0.2)	1.75 (0.09)	1.09 (0.04)	3.58 (0.7)	3.83 (0.9)	1.21 (0.4)	6.03 (1.5)
Wind	6.9 (1.5)	1.44 (0.1)	0.85 (0.1)	0.67 (0.4)	0.34 (0.1)	0.27 (0.2)	0.76 (0.4)

Appendix C. Continued (see page 77 for heading).

	Trophic guild	Tolerance category		Species		
Reach–stream	Surface- and water-column insectivore (fish/min)	Tolerant species (fish/min)	Intolerant species (fish/min)	Black bullhead (fish/min)	Blackstripe topminnow (fish/min)	Bluegill (fish/min)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0.14 (0.1)	0.06 (0.06)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	2.30 (2.1)	6.88 (4.7)	0.01 (0.01)	0 (0)	0 (0)
Fourmile	0 (0)	0.19 (0.03)	3.53 (0.5)	0 (0)	0 (0)	0 (0)
Little Arkansas	0 ([b])	1.41 ([b])	0.56 ([b])	0 ([b])	0 ([b])	0 ([b])
Rush	0 (0)	0.09 (0.09)	2.26 (2.2)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	1.35 (0.4)	1.19 (0.0004)	0.02 (0.02)	0 (0)	0 (0)
Wind	0 (0)	2.99 (0.7)	1.74 (1.1)	0.14 (0.14)	0 (0)	0.10 (0.1)
Mid						
Farnum	0.01 (0.01)	5.85 (0.7)	0.39 (0.2)	0.06 (0.06)	0 (0)	0.36 (0.1)
Forsyth	0 (0)	0.75 (0.4)	11.04 (4.4)	0 (0)	0 (0)	0 (0)
Honey	0 ([b])	0.57 ([b])	4.62 ([b])	0 ([b])	0 ([b])	0 ([b])
Little Arkansas	0 (0)	1.30 (0.3)	1.36 (0.2)	0.02 (0.02)	0 (0)	0 (0)
Timber	0 (0)	3.17 (1.3)	3.22 (1.2)	0.04 (0.03)	0 (0)	0.05 (0.02)
Wind	0 (0)	0.96 (0.4)	0.74 (0.6)	0.03 (0.03)	0 (0)	0.07 (0.01)
Lower						
Madison	0 (0)	3.36 (1.24)	4.48 (2.1)	0.08 (0.04)	0 (0)	0.50 (0.3)
Sevenmile	0 (0)	2.29 (0.6)	8.80 (2.45)	0.04 (0.02)	0 (0)	0.06 (0.02)
Threemile	0 (0)	5.79 (2.14)	4.23 (1.8)	0.02 (0.01)	0 (0)	0.67 (0.3)
Wildcat	0 (0)	15.3 (3.7)	4.12 (0.9)	0.006 (0.003)	0 (0)	0.55 (0.2)
Wind	0 (0)	1.82 (1.1)	0.77 (0.4)	0.02 (0.01)	0 (0)	0.09 (0.07)

Appendix C. Continued (see page 77 for heading).

	Species					
Reach–stream	Bluntnose minnow (fish/min)	Bullhead minnow (fish/min)	Central stoneroller (fish/min)	Channel catfish (fish/min)	Common carp (fish/min)	Common shiner (fish/min)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0.04 (0.04)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	5.72 (4.9)	0 (0)	0 (0)	0 (0)
Fourmile	0.02 (0.02)	0 (0)	1.71 (0.8)	0 (0)	0 (0)	0 (0)
Little Arkansas	0.24 ([b])	0 ([b])	0.42 ([b])	0 ([b])	0 ([b])	0.08 ([b])
Rush	0 (0)	0 (0)	0.38 (0.3)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0.79 (0.4)	0 (0)	0 (0)	0.01 (0.01)
Wind	1.15 (0.06)	1.45 (1.45)	0.14 (0.09)	0 (0)	0 (0)	0.02 (0.02)
Mid						
Farnum	1.49 (1.1)	0 (0)	0.21 (0.2)	0 (0)	0.04 (0.04)	0 (0)
Forsyth	0.04 (0.04)	0 (0)	7.75 (5.7)	0 (0)	0 (0)	0.39 (0.3)
Honey	0 ([b])	0 ([b])	4.40 ([b])	0 ([b])	0 ([b])	0 ([b])
Little Arkansas	0.21 (0.17)	0 (0)	0.62 (0.03)	0 (0)	0 (0)	0.14 (0.07)
Timber	0 (0)	0 (0)	1.34 (0.8)	0 (0)	0 (0)	0 (0)
Wind	0.20 (0.2)	0 (0)	0.41 (0.4)	0 (0)	0 (0)	0.07 (0.07)
Lower						
Madison	0.18 (0.2)	0 (0)	2.81 (1.2)	0.02 (0.02)	0 (0)	0 (0)
Sevenmile	1.54 (0.6)	0.04 (0.03)	4.76 (1.9)	0 (0)	0.02 (0.02)	0.84 (0.3)
Threemile	1.47 (0.7)	0 (0)	1.27 (0.9)	0.009 (0.006)	0.01 (0.008)	1.33 (0.7)
Wildcat	9.78 (3.0)	0.009 (0.005)	1.32 (0.4)	0.003 (0.003)	0 (0)	0.09 (0.06)
Wind	1.13 (0.65)	0.03 (0.01)	0.34 (0.2)	0 (0)	0 (0)	0.02 (0.02)

Appendix C. Continued (see page 77 for heading).

Reach–stream	Species						
	Creek chub (fish/min)	Fathead minnow (fish/min)	Golden shiner (fish/min)	Green sunfish (fish/min)	Johnny darter (fish/min)	Largemouth bass (fish/min)	Logperch (fish/min)
Headwater							
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0.02 (0.02)	0.10 (0.1)	0 (0)	0.04 (0.04)	0 (0)	0 (0)	0 (0)
Forsyth	1.16 (0.2)	1.25 (1.1)	0.29 (0.29)	0.18 (0.1)	0 (0)	0 (0)	0 (0)
Fourmile	1.31 (0.1)	0.16 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas	0.06 ([b])	0.90 ([b])	0 ([b])	0.27 ([b])	0 ([b])	0 ([b])	0 ([b])
Rush	1.89 (1.8)	0.02 (0.02)	0 (0)	0.08 (0.08)	0 (0)	0 (0)	0 (0)
Threemile	0.40 (0.4)	0.63 (0.3)	0 (0)	0.69 (0.07)	0 (0)	0 (0)	0 (0)
Wind	0.26 (0.06)	0.39 (0.19)	0 (0)	1.09 (0.4)	0 (0)	0.03 (0.03)	0 (0)
Mid							
Farnum	0.09 (0.09)	0.84 (0.1)	0 (0)	2.07 (0.6)	0.03 (0.03)	0.85 (0.6)	0 (0)
Forsyth	2.89 (1.0)	0.60 (0.3)	0 (0)	0.11 (0.1)	0 (0)	0 (0)	0 (0)
Honey	0.22 ([b])	0.55 ([b])	0 ([b])	0.02 ([b])	0 ([b])	0 ([b])	0 ([b])
Little Arkansas	0.49 (0.02)	0.35 (0.3)	0 (0)	0.55 (0.2)	0 (0)	0 (0)	0 (0)
Timber	0.77 (0.2)	1.26 (0.6)	0 (0)	0.73 (0.3)	0 (0)	0.04 (0.02)	0.07 (0.04)
Wind	0.03 (0.03)	0 (0)	0.01 (0.01)	0.54 (0.2)	0 (0)	0.10 (0.03)	0 (0)
Lower							
Madison	0.83 (0.4)	0.28 (0.09)	0 (0)	0.18 (0.1)	0.03 (0.03)	0.32 (0.2)	0.02 (0.01)
Sevenmile	1.21 (0.2)	0.16 (0.06)	0 (0)	0.04 (0.01)	0 (0)	0 (0)	0.06 (0.06)
Threemile	1.05 (0.6)	0.13 (0.1)	0 (0)	0.39 (0.3)	0 (0)	0.17 (0.09)	0.09 (0.06)
Wildcat	0.27 (0.2)	0.53 (0.5)	0 (0)	0.56 (0.1)	0 (0)	0.02 (0.01)	0.08 (0.06)
Wind	0.23 (0.08)	0.08 (0.05)	0 (0)	0.46 (0.3)	0 (0)	0.03 (0.03)	0 (0)

Appendix C. Continued (see page 77 for heading).

Reach–stream	Species					
	Longear sunfish (fish/min)	Mosquitofish (fish/min)	Orangespotted sunfish (fish/min)	Orangethroat darter (fish/min)	Red shiner (fish/min)	Redfin shiner (fish/min)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0.15 (0.2)	058 (0.6)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0.51 (0.4)	0.02 (0.02)	0 (0)
Little Arkansas	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Rush	0 (0)	0 (0)	0 (0)	0.03 (0.03)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0.01 (0.01)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0.11 (0.08)	0.07 (0.004)	1.27 (1.1)
Mid						
Farnum	0 (0)	0.02 (0.02)	0 (0)	0.77 (0.2)	0.004 (0.004)	0.09 (0.05)
Forsyth	0 (0)	0 (0)	0 (0)	0.63 (0.1)	0 (0)	0 (0)
Honey	0 ([b])	0 ([b])	0 ([b])	0.30 ([b])	0 ([b])	0 ([b])
Little Arkansas	0.03 (0.03)	0 (0)	0 (0)	0.32 (0.2)	0.18 (0.1)	0.03 (0.03)
Timber	0 (0)	0 (0)	0 (0)	0.44 (0.2)	1.02 (0.6)	0.03 (0.005)
Wind	0.21 (0.03)	0 (0)	0 (0)	0 (0)	0.01 (0.01)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0.006 (0.006)	0.23 (0.2)	1.69 (0.9)	0.03 (0.03)
Sevenmile	0.10 (0.08)	0 (0)	0.04 (0.01)	0.25 (0.1)	0.38 (0.1)	0.11 (0.1)
Threemile	0.21 (0.06)	0 (0)	0.09 (0.05)	0.12 (0.1)	2.79 (1.4)	0.12 (0.05)
Wildcat	1.06 (0.4)	0 (0)	0.19 (0.15)	0.33 (0.2)	3.61 (0.9)	0.61 (0.3)
Wind	0.04 (0.02)	0 (0)	0 (0)	0.08 (0.07)	0.01 (0.01)	0.05 (0.05)

Appendix C. Continued (see page 77 for heading).

	Species					
Reach–stream	River carpsucker (fish/min)	Sand shiner (fish/min)	Shorthead redhorse (fish/min)	Slender madtom (fish/min)	Southern redbelly dace (fish/min)	Spotted bass (fish/min)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0.51 (0.1)	0 (0)
Little Arkansas	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0.03 (0.03)	0 (0)	0.01 (0.01)
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Little Arkansas	0 (0)	0.02 (0.02)	0 (0)	0.03 (0.03)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0.02 (0.02)	0 (0)	0 (0)
Lower						
Madison	0.15 (0.2)	0.05 (0.05)	0 (0)	0 (0)	0 (0)	0 (0)
Sevenmile	0 (0)	0.05 (0.03)	0 (0)	0.41 (0.2)	0.60 (0.4)	0 (0)
Threemile	0.02 (0.02)	0.03 (0.03)	0.004 (0.004)	0.11 (0.07)	0.004 (0.004)	0.03 (0.03)
Wildcat	0 (0)	0.006 (0.006)	0.05 (0.01)	0.26 (0.06)	0 (0)	0.03 (0.01)
Wind	0 (0)	0.01 (0.01)	0 (0)	0.08 (0.05)	0 (0)	0 (0)

Appendix C. Continued (see page 77 for heading).

Reach–stream	Species					
	Stonecat (fish/min)	Suckermouth minnow (fish/min)	Topeka shiner (fish/min)	Walleye (fish/min)	White crappie (fish/min)	White sucker (fish/min)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.05 (0.02)
Little Arkansas	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.44 (0.42)
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Little Arkansas	0 (0)	0 (0)	0.01 (0.01)	0 (0)	0 (0)	0.08 (0.08)
Timber	0 (0)	1.08 (0.9)	0 (0)	0 (0)	0 (0)	0.008 (0.005)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0.02 (0.02)	0.81 (0.6)	0 (0)	0.006 (0.006)	0 (0)	0.47 (0.27)
Sevenmile	0.003 (0.002)	0.77 (0.6)	0 (0)	0 (0)	0 (0)	0.18 (0.04)
Threemile	0 (0)	0.09 (0.09)	0 (0)	0 (0)	0 (0)	0.06 (0.04)
Wildcat	0.02 (0.008)	0.42 (0.09)	0 (0)	0 (0)	0 (0)	0.17 (0.09)
Wind	0 (0)	0 (0)	0.007 (0.007)	0 (0)	0 (0)	0 (0)

Appendix C. Continued (see page 77 for heading).

	Species			
Reach–stream	Yellow bullhead (fish/min)	Green sunfish *x* Bluegill (fish/min)	Green sunfish *x* Orangespotted sunfish (fish/min)	Longear sunfish *x* Bluegill (fish/min)
Headwater				
Dry	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Rush	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0.02 (0.01)	0 (0)	0 (0)	0 (0)
Mid				
Farnum	0.08 (0.08)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0.04 (0.03)	0 (0)	0 (0)	0 (0)
Wind	0.01 (0.01)	0 (0)	0 (0)	0 (0)
Lower				
Madison	0.09 (0.06)	0 (0)	0 (0)	0 (0)
Sevenmile	0.02 (0.02)	0 (0)	0 (0)	0 (0)
Threemile	0.03 (0.02)	0.03 (0.03)	0.02 (0.02)	0.26 (0.2)
Wildcat	0.006 (0.006)	0 (0)	0 (0)	0.15 (0.15)
Wind	0 (0)	0.006 (0.006)	0 (0)	0.006 (0.006)

[a] Community indices were only available from one sub-sample.
[b] Only one sub-sample was sampled.

Appendix D. Catch per unit effort (fish/m of **seining**) by **trophic guild** and **species** sampled in **pool** macrohabitats from streams on Fort Riley Military Reservation during June and July 1997, 1998. Number in parenthesis represents standard error.

	Trophic guild				
Reach–stream	Benthic-insectivore (fish/m)	Generalized-insectivore (fish/m)	Insectivore-piscivore (fish/m)	Omnivore (fish/m)	Surface- and water-column insectivore (fish/m)
Headwater					
Dry	0.5 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0.30 (0.3)	4.90 (3.1)	0 (0)	2.26 (1.5)	0
Fourmile	0.88 (0.1)	16.6 (2.9)	0 (0)	0.13 (0.13)	0 (0)
Little Arkansas	0.75 ([a])	2.75 ([a])	0 ([a])	0.38 ([a])	0 ([a])
Rush	0.25 (0.25)	0.63 (0.3)	0 (0)	0 (0)	0 (0)
Threemile	0.10 (0.1)	1.23 (0.6)	1.17 (1.2)	0.67 (0.67)	0 (0)
Wind	0.67 (0.3)	33.1 (28.9)	0 (0)	1.77 (0.9)	0 (0)
Mid					
Farnum	0.14 (0.1)	9.17 (7.0)	23.66 (7.9)	5.13 (2.73)	0 (0)
Forsyth	0.07 (0.07)	2.50 (1.5)	0.07 (0.07)	0.54 (0.3)	0 (0)
Honey	0.20 ([a])	0 ([a])	0 ([a])	1.00 ([a])	0 ([a])
Little Arkansas	1.25 (0.7)	20.75 (14.8)	0.25 (0.25)	1.50 (0.5)	0 (0)
Timber	0.23 (0.08)	17.67 (5.2)	0.63 (0.54)	1.56 (0.7)	0 (0)
Wind	0.08 (0.08)	2.58 (2.6)	2.58 (2.42)	0.08 (0.08)	0 (0)
Lower					
Madison	1.1 (0.4)	44.02 (15.4)	4.00 (2.1)	1.42 (0.3)	0 (0)
Sevenmile	0.88 (0.46)	37.9 (13.1)	0.23 (0.1)	2.95 (0.9)	0 (0)
Threemile	0.10 (0.05)	80.37 (43.4)	0.40 (0.2)	2.77 (2.3)	0 (0)
Wildcat	1.79 (1.33)	147.13 (31.2)	2.81 (2.4)	3.54 (1.3)	0 (0)
Wind	0.09 (0.05)	29.96 (11.5)	1.79 (0.5)	2.33 (0.7)	0.04 (0.04)

Appendix D. Continued (see page 85 for heading).

	Species					
Reach–stream	Black bullhead (fish/m)	Blackstripe topminnow (fish/m)	Bluegill (fish/m)	Bluntnose minnow (fish/m)	Bullhead minnow (fish/m)	Central stoneroller (fish/m)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (0.02)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.003 (0.003)
Little Arkansas	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.008 (0.008)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.003 (0.003)
Wind	0 (0)	0 (0)	0 (0)	0.05 (0.02)	0 (0)	0.005 (0.005)
Mid						
Farnum	0 (0)	0 (0)	0.004 (0.002)	0.01 (0.01)	0 (0)	0.009 (0.009)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.02 (0.02)
Honey	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0.04 ([a])
Little Arkansas	0 (0)	0 (0)	0 (0)	0.02 (0.02)	0 (0)	0 (0)
Timber	0.003 (0.002)	0 (0)	0.02 (0.02)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0.005 (0.005)	0 (0)	0 (0)
Lower						
Madison	0.007 (0.007)	0 (0)	0.01 (0.005)	0.001 (0.001)	0 (0)	0.02 (0.01)
Sevenmile	0.02 (0.02)	0 (0)	0.01 (0.007)	0.03 (0.009)	0 (0)	0.006 (0.004)
Threemile	0.001 (0.001)	0 (0)	0 (0)	0.03 (0.03)	0 (0)	0 (0)
Wildcat	0 (0)	0 (0)	0.001 (0.001)	0.04 (0.02)	0 (0)	0 (0)
Wind	0.003 (0.003)	0.001 (0.001)	0.009 (0.003)	0.04 (0.01)	0 (0)	0.05 (0.05)

Appendix D. Continued (see page 85 for heading).

Reach–stream	Species					
	Channel catfish (fish/m)	Common carp (fish/m)	Common shiner (fish/m)	Creek chub (fish/m)	Fathead minnow (fish/m)	Golden shiner (fish/m)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0.18 (0.1)	0.08 (0.04)	0.009 (0.009)
Fourmile	0 (0)	0 (0)	0 (0)	0.24 (0.04)	0.004 (0.004)	0 (0)
Little Arkansas	0 ([a])	0 ([a])	0.02 ([a])	0.13 ([a])	0.01 ([a])	0 ([a])
Rush	0 (0)	0 (0)	0 (0)	0.04 (0.03)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0.003 (0.003)	0.02 (0.02	0.01 (0.01)	0 (0)
Wind	0 (0)	0 (0)	0.04 (0.04)	0.02 (0.02)	0.008 (0.008)	0 (0)
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0.17 (0.006)	0.02 (0.009)
Forsyth	0 (0)	0 (0)	0.09 (0.08)	0.05 (0.01)	0.02 (0.002)	0 (0)
Honey	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0.08 ([a])	0 ([a])
Little Arkansas	0 (0)	0 (0)	0.20 (0.1)	0.02 (0.01)	0.03 (0.02)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0.04 (0.008)	0.05 (0.03)	0 (0)
Wind	0 (0)	0 (0)	0.06 (0.06)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0 (0)	0.05 (0.05)	0.005 (0.003)	0.004 (0.004)
Sevenmile	0 (0)	0 (0)	0.85 (0.3)	0.04 (0.03)	0.008 (0.008)	0 (0)
Threemile	0 (0)	0.0008 (0.0008)	0.56 (0.3)	0.01 (0.01)	0.0008 (0.0008)	0 (0)
Wildcat	0 (0)	0 (0)	0.07 (0.03)	0.007 (0.007)	0.005 (0.003)	0 (0)
Wind	0 (0)	0 (0)	0.36 (0.1)	0.03 (0.02)	0.04 (0.02)	0 (0)

Appendix D. Continued (see page 85 for heading).

Reach–stream	Species					
	Green sunfish (fish/m)	Johnny darter (fish/m)	Largemouth bass (fish/m)	Logperch (fish/m)	Longear sunfish (fish/m)	Mosquitofish (fish/m)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0.13 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mid						
Farnum	0.02 (0.02)	0.0009 (0.0009)	0.30 (0.02)	0 (0)	0 (0)	0.01 (0.01)
Forsyth	0.003 (0.003)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Little Arkansas	0.009 (0.009)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0.0008 (0.0008)	0.003 (0.003)	0.006 (0.006)	0 (0)	0 (0)
Wind	0.005 (0.005)	0 (0)	0.01 (0.01)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0.02 (0.02)	0 (0)	0.08 (0.08)	0 (0)	0 (0)	0 (0)
Sevenmile	0 (0)	0 (0)	0 (0)	0.02 (0.02)	0.001 (0.001)	0 (0)
Threemile	0 (0)	0 (0)	0.002 (0.001)	0 (0)	0.002 (0.001)	0 (0)
Wildcat	0 (0)	0 (0)	0.006 (0.005)	0.001 (0.001)	0.03 (0.02)	0 (0)
Wind	0.001 (0.001)	0 (0)	0.05 (0.03)	0 (0)	0 (0)	0 (0)

Appendix D. Continued (see page 85 for heading).

Reach–stream	Species					
	Orangespotted sunfish (fish/m)	Orangethroat darter (fish/m)	Red shiner (fish/m)	Redfin shiner (fish/m)	River carpsucker (fish/m)	Sand shiner (fish/m)
Headwater						
Dry	0 (0)	0.002 (0.002)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0.01 (0.01)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0.01 (0.01)	0.01 (0.004)	0 (0)	0 (0)	0 (0)
Little Arkansas	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Rush	0 (0)	0.005 (0.005)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0.02 (0.009)	0 (0)	0 (0)
Wind	0 (0)	0.001 (0.001)	0.08 (0.03)	0.70 (0.6)	0 (0)	0 (0)
Mid						
Farnum	0 (0)	0.004 (0.004)	0.004 (0.004)	0.24 (0.2)	0 (0)	0 (0)
Forsyth	0 (0)	0.009 (0.009)	0.003 (0.003)	0 (0)	0 (0)	0 (0)
Honey	0 ([a])	0.03 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Little Arkansas	0 (0)	0 (0)	0.16 (0.1)	0.33 (0.3)	0 (0)	0.01 (0.01)
Timber	0 (0)	0.003 (0.002)	0.36 (0.1)	0.20 (0.07)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0.07 (0.07)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0.004 (0.004)	0.70 (0.3)	0.03 (0.02)	0 (0)	0 (0)
Sevenmile	0 (0)	0.003 (0.003)	0.17 (0.06)	0.24 (0.2)	0 (0)	0.02 (0.01)
Threemile	0 (0)	0 (0)	0.34 (0.08)	0.20 (0.09)	0 (0)	0 (0)
Wildcat	0.0008 (0.0008)	0.005 (0.005)	1.64 (0.6)	0.84 (0.2)	0 (0)	0.001 (0.001)
Wind	0 (0)	0.002 (0.001)	0.08 (0.04)	0.47 (0.2)	0 (0)	0.002 (0.002)

Appendix D. Continued (see page 85 for heading).

	Species					
Reach–stream	Shorthead redhorse (fish/m)	Slender madtom (fish/m)	Southern redbelly dace (fish/m)	Spotted bass (fish/m)	Stonecat (fish/m)	Suckermouth minnow (fish/m)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0.31 (0.07)	0 (0)	0 (0)	0 (0)
Little Arkansas	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0.004 (0.004)	0 (0)	0 (0)	0 (0)	0 (0)
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Little Arkansas	0 (0)	0.009 (0.009)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0.005 (0.005)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sevenmile	0 (0)	0.04 (0.02)	0.04 (0.02)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0.004 (0.004)	0 (0)	0 (0)	0.004 (0.004)	0 (0)
Wildcat	0.002 (0.002)	0.01 (0.009)	0 (0)	0.002 (0.002)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix D. Continued (see page 85 for heading).

Reach–stream	Species					
	Topeka shiner (fish/m)	Walleye (fish/m)	White crappie (fish/m)	White sucker (fish/m)	Yellow bullhead (fish/m)	Green sunfish *x* Bluegill (fish/m)
Headwater						
Dry	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0.01 (0.007)	0 (0)	0 (0)
Little Arkansas	0 ([a])	0 ([a])	0 ([a])	0.04 ([a])	0 ([a])	0 ([a])
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0.003 (0.003)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0.02 (0.02)	0 (0)	0 (0)
Mid						
Farnum	0 (0)	0 (0)	0.0008 (0.0008)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])	0 ([a])
Little Arkansas	0 (0)	0 (0)	0 (0)	0.009 (0.009)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0.002 (0.002)	0.004 (0.003)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0.0005 (0.0005)	0.02 (0.01)	0.02 (0.01)	0 (0)
Sevenmile	0 (0)	0 (0)	0 (0)	0.002 (0.002)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	0 (0)	0 (0)	0.009 (0.009)	0 (0)	0 (0)
Wind	0.0008 (0.0008)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix D. Continued (see page 85 for heading).

Reach–stream	Species: Green sunfish *x* Orangespotted sunfish (fish/m)	Species: Longear sunfish *x* Bluegill (fish/m)
Headwater		
Dry	0 (0)	0 (0)
Farnum	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)
Little Arkansas	0 ([a])	0 ([a])
Rush	0 (0)	0 (0)
Threemile	0 (0)	0 (0)
Wind	0 (0)	0 (0)
Mid		
Farnum	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)
Honey	0 ([a])	0 ([a])
Little Arkansas	0 (0)	0 (0)
Timber	0 (0)	0 (0)
Wind	0 (0)	0 (0)
Lower		
Madison	0 (0)	0 (0)
Sevenmile	0 (0)	0 (0)
Threemile	0 (0)	0.001 (0.001)
Wildcat	0 (0)	0.0007 (0.0007)
Wind	0 (0)	0 (0)

[a] Only one sub-sample was sampled.

Appendix E. Fish **community indices** and catch per unit effort (fish/min of **electrofishing**) by **trophic guild**, and **tolerance category**, and **species** in **riffle** macrohabitats from streams on Fort Riley Military Reservation sampled during June and July 1997, 1998. Number in parenthesis represent standard error.

	Community index			Trophic guild			
Reach–stream	Species richness (S)	Species diversity (H_S')	Trophic guild diversity (H_T')	Benthic-insectivore (fish/min)	Generalized-insectivore (fish/min)	Insectivore-piscivore (fish/min)	Omnivore (fish/min)
Headwater							
Dry[a]							
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	2.4 (1.9)	0.54 (0.5)	0.52 (0.52)	1.52 (1.52)	0.53 (0.05)	0.01 (0.01)	0.34 (0.3)
Fourmile	2.0 (0)	0.56 (0.03)	0.40 (0.05)	0.49 (0.2)	1.47 (0.1)	0 (0)	0 (0)
Little Arkansas[a]							
Rush	0.4 (0.08)	0 (0)	0 (0)	0.20 (0.2)	0.61 (0.6)	0 (0)	0 (0)
Threemile	0.3 (0.07)	0 (0)	0 (0)	0.09 (0.09)	0 (0)	0 (0)	0 (0)
Wind	2.0 ([b])	0.50 ([b])	0.50 ([b])	1.44 ([b])	0 ([b])	0 ([b])	2.58 ([b])
Mid							
Farnum	1.4 (0.1)	0.41 (0.1)	0.36 (0.2)	1.26 (0.4)	0.08 (0.08)	0.11 (0.1)	0.22 (0.2)
Forsyth	1.0 (0.3)	0.22 (0.01)	0.22 (0.01)	1.33 (0.8)	0 (0)	0 (0)	0 (0)
Honey	1.4 ([c])	0.23 ([c])	0.23 ([c])	1.16 ([c])	0.06 ([c])	0 ([c])	0 ([c])
Little Arkansas	1.5 (1.5)	0.88 (0)	0.65 (0)	1.03 (1.03)	0 (0)	0 (0)	0 (0)
Timber	2.3 (0.6)	0.48 (0.1)	0.36 (0.1)	3.33 (0.9)	0.37 (0.2)	0.009 (0.009)	0.02 (0.02)
Wind	1.0 (1.0)	0.38 (0)	0.38 (0)	0.57 (0.57)	0.63 (0.6)	0 (0)	0.18 (0.2)
Lower							
Madison	5.3 (0.3)	1.04 (0.05)	0.79 (0.1)	4.92 (1.7)	4.38 (2.4)	0 (0)	0.31 (0.3)
Sevenmile	5.7 (0.7)	1.22 (0.2)	0.75 (0.1)	1.81 (0.9)	1.44 (0.6)	0.10 (0.06)	0.46 (0.2)
Threemile	3.1 (1.2)	0.60 (0.2)	0.41 (0.2)	2.87 (1.5)	0.91 (0.1)	0 (0)	1.52 (1.3)
Wildcat	8.3 (1.1)	1.47 (0.1)	1.01 (0.09)	5.61 (1.5)	3.28 (1.3)	0.18 (0.1)	2.61 (0.9)
Wind	1.9 (1.3)	0.55 (0.46)	0.40 (0.3)	1.11 (0.6)	0.27 (0.27)	0.03 (0.03)	0.29 (0.3)

Appendix E. Continued (see page 93 for heading).

	Trophic guild	Species				
Reach–stream	Surface- and water-column insectivore (fish/min)	Tolerant species (fish/min)	Intolerant species (fish/min)	Black bullhead (fish/min)	Blackstripe topminnow (fish/min)	Bluegill (fish/min)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0.35 (0.4)	2.94 (2.4)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	2.21 (0.6)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0.61 (0.6)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	2.58 ([b])	0 ([b])	0 ([b])	0 ([b])	0([b])
Mid						
Farnum	0 (0)	0.33 (0.3)	0.08 (0.08)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0.09 (0.06)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0.20 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0.47 (0.5)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0.17 (0.2)	0.86 (0.7)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0.18 (0.2)	0.95 (0.9)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	4.25 (2.3)	5.73 (4.2)	0.14 (0.1)	0 (0)	0 (0)
Sevenmile	0 (0)	0.91 (0.2)	3.58 (0.5)	0 (0)	0 (0)	0.03 (0.02)
Threemile	0 (0)	1.97 (1.2)	1.20 (0.5)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	5.76 (1.9)	4.95 (1.8)	0 (0)	0 (0)	0.06 (0.05)
Wind	0 (0)	0.39 (0.39)	0.63 (0.6)	0 (0)	0 (0)	0 (0)

Appendix E. Continued (see page 93 for heading).

	Species					
Reach–stream	Bluntnose minnow (fish/min)	Bullhead minnow (fish/min)	Central stoneroller (fish/min)	Channel catfish (fish/min)	Common carp (fish/min)	Common shiner (fish/min)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	2.40 (2.4)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0.74 (0.5)	0 (0)	0 (0)	0.34 (0.34)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	2.58 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0.09 (0.06)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0.14 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0.40 (0.4)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0.81 (0.7)	0 (0)	0 (0)	0 (0)
Wind	0.18 (0.2)	0 (0)	0.32 (0.3)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	4.63 (4.3)	0 (0)	0 (0)	0 (0)
Sevenmile	0.40 (0.2)	0 (0)	1.95 (0.4)	0 (0)	0 (0)	0.21 (0.09)
Threemile	1.06 (0.9)	0 (0)	0.46 (0.2)	0 (0)	0 (0)	0 (0)
Wildcat	2.56 (0.8)	0.007 (0.007)	1.66 (0.9)	0 (0)	0 (0)	0.08 (0.03)
Wind	0.27 (0.3)	0 (0)	0.24 (0.2)	0 (0)	0 (0)	0 (0)

Appendix E. Continued (see page 93 for heading).

Reach–stream	Species: Creek chub (fish/min)	Fathead minnow (fish/min)	Golden shiner (fish/min)	Green sunfish (fish/min)	Johnny darter (fish/min)	Largemouth bass (fish/min)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0.53 (0.05)	0.34 (0.3)	0 (0)	0.02 (0.02)	0 (0)	0 (0)
Fourmile	0.26 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0.61 (0.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0.08 (0.08)	0.22 (0.2)	0 (0)	0.11 (0.1)	0.75 (0.7)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0.06 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0.04 (0.02)	0.02 (0.02)	0 (0)	0.008 (0.008)	0.13 (0.13)	0 (0)
Wind	0.90 (0.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0.33 (0.3)	0 (0)	0 (0)	0 (0)	0.22 (0.2)	0 (0)
Sevenmile	0.38 (0.2)	0.06 (0.04)	0 (0)	0 (0)	0.02 (0.02)	0 (0)
Threemile	0.44 (0.2)	0.46 (0.5)	0 (0)	0 (0)	0.08 (0.08)	0 (0)
Wildcat	0.07 (0.03)	0.06 (0.06)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0.19 (0.1)	0 (0)	0 (0)	0.03 (0.03)	0.01 (0.01)	0 (0)

Appendix E. Continued (see page 93 for heading).

Reach–stream	Species					
	Logperch (fish/min)	Longear sunfish (fish/min)	Mosquitofish (fish/min)	Orangespotted sunfish (fish/min)	Orangethroat darter (fish/min)	Red shiner (fish/min)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	1.52 (1.5)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0.49 (0.2)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.1)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0.09 (0.08)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	1.44 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0.52 (0.29)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	1.33 (0.7)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	1.16 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0.96 (0.9)	0 (0)
Timber	0.19 (0.1)	0 (0)	0 (0)	0 (0)	3.19 (0.9)	0.14 (0.1)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0.57 (0.6)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0 (0)	0 (0)	3.92 (1.1)	4.05 (2.0)
Sevenmile	0 (0)	0 (0)	0 (0)	0.07 (0.07)	1.22 (0.8)	0.35 (0.09)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	2.41 (1.2)	0.45 (0.3)
Wildcat	0.07 (0.05)	0.05 (0.05)	0 (0)	0.08 (0.06)	2.46 (0.6)	3.01 (1.3)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0.89 (0.3)	0.08 (0.08)

Appendix E. Continued (see page 93 for heading).

	Species					
Reach–stream	Redfin shiner (fish/min)	River carpsucker (fish/min)	Sand shiner (fish/min)	Shorthead redhorse (fish/min)	Slender madtom (fish/min)	Southern redbelly dace (fish/min)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.87 (0.2)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (0.06)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0.11 (0.1)	0 (0)	0.07 (0.06)	0 (0)
Sevenmile	0.09 (0.09)	0 (0)	0 (0)	0 (0)	0.34 (0.1)	0.41 (0.3)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0.28 (0.1)	0.02 (0.02)
Wildcat	0.04 (0.01)	0 (0)	0 (0)	0.09 (0.05)	2.06 (0.7)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0.20 (0.2)	0 (0)

Appendix E. Continued (see page 93 for heading).

	Species					
Reach–stream	Spotted bass (fish/min)	Stonecat (fish/min)	Suckermouth minnow (fish/min)	Topeka shiner (fish/min)	Walleye (fish/min)	White crappie (fish/min)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0.009 (0.009)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0.71 (0.4)	0 (0)	0 (0)	0 (0)
Sevenmile	0 (0)	0 (0)	0.20 (0.1)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	0.05 (0.01)	0.90 (0.5)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix E. Continued (see page 93 for heading).

	Species				
Reach–stream	White sucker (fish/min)	Yellow bullhead (fish/min)	Green sunfish *x* Bluegill (fish/min)	Green sunfish *x* Orangespotted sunfish (fish/min)	Longear sunfish *x* Bluegill (fish/min)
Headwater					
Dry[a]					
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]					
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid					
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower					
Madison	0 (0)	0.07 (0.07)	0 (0)	0 (0)	0 (0)
Sevenmile	0.03 (0.02)	0 (0)	0 (0)	0 (0)	0.02 (0.02)
Threemile	0.11 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)
Wildcat	0.04 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0.01 (0.01)	0 (0)	0 (0)	0 (0)

[a] Riffle macrohabitats were absent. [b] Riffle macrohabitats were only present at one sub-sample. [c] Only one sub-sample was sampled.

Appendix F. Catch per unit effort (fish/m of **seining**) by **trophic guild** and **species** sampled in **riffle** macrohabitats from streams on Fort Riley Military Reservation during June and July 1997, 1998. Number in parenthesis represents standard error.

	Trophic guild				
Reach–stream	Benthic-insectivore (fish/m)	Generalized-insectivore (fish/m)	Insectivore-piscivore (fish/m)	Omnivore (fish/m)	Surface- and water-column insectivore (fish/m)
Headwater					
Dry[a]					
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0.22 (0.2)	0.30 (0.1)	0 (0)	0.19 (0.2)	0 (0)
Fourmile	0.10 (0.1)	0.24 (0.2)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]					
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0.02 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0.46 ([b])	0 ([b])
Mid					
Farnum	0.22 (0.1)	0 (0)	0.07 (0.03)	0 (0)	0 (0)
Forsyth	0.26 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0.03 ([c])	0 ([c])	0 ([c])	0.07 ([c])	0 ([c])
Little Arkansas	0.21 (0.2)	0.30 (0.3)	0 (0)	0.03 (0.03)	0 (0)
Timber	0.31 (0.2)	0.15 (0.08)	0.02 (0.02)	0.006 (0.006)	0 (0)
Wind	0.03 (0.03)	0 (0)	0 (0)	0 (0)	0 (0)
Lower					
Madison	1.81 (1.7)	1.25 (0.8)	0.05 (0.05)	0.06 (0.06)	0 (0)
Sevenmile	0.26 (0.2)	0.41 (0.07)	0.009 (0.009)	0.03	0 (0)
Threemile	0.06 (0.04)	0.09 (0.04)	0.003 (0.003)	0.02 (0.02)	0 (0)
Wildcat	0.51 (0.06)	0.90 (0.3)	0.003 (0.002)	0.16 (0.09)	0 (0)
Wind	0.12 (0.08)	0 (0)	0.02 (0.02)	0.004 (0.004)	0 (0)

Appendix F. Continued (see page 101 for heading).

Reach–stream	Species					
	Black bullhead (fish/m)	Blackstripe topminnow (fish/m)	Bluegill (fish/m)	Bluntnose minnow (fish/m)	Bullhead minnow (fish/m)	Central stoneroller (fish/m)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.18 (0.1)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0.02 (0.02)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0.46 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.03 (0.03)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0.04 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.003 (0.003)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0.01 (0.01)	0 (0)	0 (0)	0 (0)	0 (0)	0.16 (0.1)
Sevenmile	0 (0)	0 (0)	0 (0)	0.02 (0.01)	0 (0)	0.02 (0.01)
Threemile	0 (0)	0 (0)	0 (0)	0.02 (0.02)	0 (0)	0.01 (0.01)
Wildcat	0 (0)	0 (0)	0 (0)	0.15 (0.07)	0 (0)	0.02 (0.009)
Wind	0 (0)	0 (0)	0 (0)	0.004 (0.004)	0 (0)	0.004 (0.004)

Appendix F. Continued (see page 101 for heading).

	Species					
Reach–stream	Channel catfish (fish/m)	Common carp (fish/m)	Common shiner (fish/m)	Creek chub (fish/m)	Fathead minnow (fish/m)	Golden shiner (fish/m)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0.30 (0.1)	0.16 (0.2)	0.03 (0.03)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0.07 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0.13 (0.1)	0 (0)	0.03 (0.03)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0.8 (0.06)	0.006 (0.006)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0 (0)	0.03 (0.03)	0 (0)	0 (0)
Sevenmile	0 (0)	0 (0)	0.20 (0.08)	0.03 (0.02)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	0 (0)	0.03 (0.03)	0 (0)	0.01 (0.01)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix F. Continued (see page 101 for heading).

	Species					
Reach–stream	Green sunfish (fish/m)	Johnny darter (fish/m)	Largemouth bass (fish/m)	Logperch (fish/m)	Longear sunfish (fish/m)	Mosquitofish (fish/m)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0.03 (0.03)	0.07 (0.03)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0.02 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0.05 (0.05)	0 (0)	0 (0)	0 (0)
Sevenmile	0 (0)	0 (0)	0 (0)	0.004 (0.004)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0.002 (0.002)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	0 (0)	0.002 (0.002)	0.01 (0.01)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix F. Continued (see page 101 for heading).

	Species					
Reach–stream	Orangespotted sunfish (fish/m)	Orangethroat darter (fish/m)	Red shiner (fish/m)	Redfin shiner (fish/m)	River carpsucker (fish/m)	Sand shiner (fish/m)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0.22 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0.10 (0.10)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0.02 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0.19 (0.15)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0.26 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0.03 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0.21 (0.2)	0.03 (0.03)	0.15 (0.2)	0 (0)	0 (0)
Timber	0 (0)	0.31 (0.2)	0.06 (0.04)	0.01 (0.01)	0 (0)	0 (0)
Wind	0 (0)	0.03 (0.03)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	1.24 (1.1)	1.23 (1.1)	0 (0)	0 (0)	0 (0)
Sevenmile	0.009 (0.009)	0.19 (0.1)	0.12 (0.04)	0.03 (0.01)	0 (0)	0.01 (0.01)
Threemile	0 (0)	0.06 (0.03)	0.09 (0.07)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	0.24 (0.06)	0.82 (0.04)	0.04 (0.01)	0 (0)	0 (0)
Wind	0 (0)	0.08 (0.04)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix F. Continued (see page 101 for heading).

	Species					
Reach–stream	Shorthead redhorse (fish/m)	Slender madtom (fish/m)	Southern redbelly dace (fish/m)	Spotted bass (fish/m)	Stonecat (fish/m)	Suckermouth minnow (fish/m)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0.24 (0.1)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.56 (0.6)
Sevenmile	0 (0)	0.06 (0.03)	0.04 (0.01)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildcat	0.006 (0.006)	0.17 (0.05)	0 (0)	0 (0)	0 (0)	0.06 (0.03)
Wind	0 (0)	0.04 (0.04)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix F. Continued (see page 101 for heading).

	Species					
Reach–stream	Topeka shiner (fish/m)	Walleye (fish/m)	White crappie (fish/m)	White sucker (fish/m)	Yellow bullhead (fish/m)	Green sunfish *x* Bluegill (fish/m)
Headwater						
Dry[a]						
Farnum	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Little Arkansas[a]						
Rush	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])	0 ([b])
Mid						
Farnum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Timber	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lower						
Madison	0 (0)	0 (0)	0 (0)	0 (0)	0.05 (0.05)	0 (0)
Sevenmile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Threemile	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wildcat	0 (0)	0 (0)	0 (0)	0.03 (0.01)	0 (0)	0 (0)
Wind	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Appendix F. Continued (see page 101 for heading).

	Species	
Reach–stream	Green sunfish *x* Orangespotted sunfish (fish/m)	Longear sunfish *x* Bluegill (fish/m)
Headwater		
Dry[a]		
Farnum	0 ([b])	0 ([b])
Forsyth	0 (0)	0 (0)
Fourmile	0 (0)	0 (0)
Little Arkansas[a]		
Rush	0 (0)	0 (0)
Threemile	0 (0)	0 (0)
Wind	0 ([b])	0 ([b])
Mid		
Farnum	0 (0)	0 (0)
Forsyth	0 (0)	0 (0)
Honey	0 ([c])	0 ([c])
Little Arkansas	0 (0)	0 (0)
Timber	0 (0)	0 (0)
Wind	0 (0)	0 (0)
Lower		
Madison	0 (0)	0 (0)
Sevenmile	0 (0)	0 (0)
Threemile	0 (0)	0 (0)
Wildcat	0 (0)	0 (0)
Wind	0 (0)	0 (0)

[a] Riffle macrohabitats were absent. [b] Riffle macrohabitats were only present at one sub-sample. [c] Only one sub-sample was sampled.

Appendix G. Mean **back-calculated length** at age (mm) for central stonerollers, creek chubs, red shiners, and green sunfish from streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Number in parenthesis represents standard error.

	Mean back-calculated length at age for central stonerollers		
Reach–stream	1	2	3
Headwater			
Dry[a]			
Farnum	48.2 (48.2)		
Forsyth	60.9 (60.9)		
Fourmile	47.9 (0.2)	70.6 (70.6)	
Little Arkansas	62.2 ([b])	90.49 ([b])	
Rush	58.9 (0.09)	88.8 (88.8)	
Threemile	47.1 (1.5)	76.3 (10.2)	
Wind	52.0 (52.0)	70.6 (70.6)	
Mid			
Farnum	65.8 (1.7)	91.3 (91.3)	
Forsyth	54.2 (1.3)	77.7 ([b])	
Honey	50.2 ([b])		
Little Arkansas	61.0 (0.98)		
Timber	53.8 (1.5)	85.2 (4.2)	96.5 (96.5)
Wind	59.7 (59.7)		
Lower			
Madison	55.1 (0.4)	84.0 (4.3)	
Sevenmile	45.8 (1.2)	70.3 (70.3)	
Threemile	55.6 (0.5)	82.7 (82.7)	
Wildcat	53.9 (2.4)	78.2 (7.4)	
Wind	60.8 (0.22)	88.7 (3.6)	145.1 (145.1)

Appendix G. Continued (see page 109 for heading).

	Mean back-calculated length at age for creek chubs				Mean back-calculated length at age for red shiners	
Reach–stream	1	2	3	4	1	2
Headwater						
Dry[a]						
Farnum						
Forsyth	64.5 (4.9)	87.8 (7.4)				
Fourmile	52.4 (4.9)	95.7 (5.4)	148.4 (148.4)		33.7 (1.2)	53.1 (53.1)
Little Arkansas	57.6 ([b])					
Rush	30.4 (5.6)	107.0 (107.0)	161.1 (161.1)	196.1 (196.1)		
Threemile	49.6 (49.6)	85.3 (85.3)				
Wind	76.3 (13.6)	116.1 (116.1)	142.4 (142.4)		41.9 (0.5)	58.4 (58.4)
Mid						
Farnum	60.2 (60.2)	91.5 (91.5)	124.9 (124.9)		26.6 ([b])	
Forsyth	70.1 (1.9)	111.1 (7.2)	174.8 (174.8)			
Honey	55.6 ([b])	98.9 ([b])				
Little Arkansas	73.8 (4.3)	111.2 (111.2)			38.7 (4.7)	64.6 (64.6)
Timber	65.7 (1.7)	111.1 (2.6)	158.9 (6.8)	187.4 (187.4)	45.8 (1.2)	61.9 (2.1)
Wind	54.4 (54.4)	92.3 (92.3)			24.7 (24.7)	
Lower						
Madison	58.3 (1.7)	96.8 (3.8)	126.3 (11.1)		40.1 (2.1)	67.1 (1.5)
Sevenmile	59.3 (5.0)	90.6 (9.8)	119.4 (11.9)		38.7 (1.1)	60.8 (0.3)
Threemile	58.1 (2.8)	103.6 (3.6)	134.9 (3.7)	162.2 (162.2)	38.0 (2.7)	49.6 (49.6)
Wildcat	80.9 (3.9)	108.4 (2.3)	149.7 (149.7)		36.7 (1.9)	52.8 (4.4)
Wind	71.5 (5.9)	116.6 (21.7)			40.9 (3.7)	

Appendix G. Continued (see page 109 for heading).

	Mean back-calculated length at age for green sunfish						
Reach–stream	1	2	3	4	5	6	7
Headwater							
Dry[a]							
Farnum	49.4 (49.4)	78.3 (78.3)	99.5 (99.5)				
Forsyth	54.5 (4.8)	94.5 (13.3)	103.2 (14.2)				
Fourmile							
Little Arkansas	56.1 ([b])	82.7 ([b])	122.9 ([b])				
Rush	50.2 (4.3)	81.7 (6.2)	95.9 (95.9)				
Threemile	38.3 (0.8)	58.9 (3.5)	82.9 (5.9)	98.9 (20.6)			
Wind	37.6 (1.4)	57.6 (4.3)	83.2 (7.6)	118.8 (9.3)	154.9 (2.4)	167.2 (167.2)	
Mid							
Farnum	40.5 (2.4)	64.9 (4.2)	94.1 (4.3)	117.9 (7.1)	141.8 (141.8)		
Forsyth	45.8 (2.9)	74.8 (4.1)	99.8 (6.9)	127.1 (3.9)	148.6 (6.7)	167.7 (12.6)	204.6 (204.6)
Honey	44.7 ([b])	88.3 ([b])					
Little Arkansas	43.9 (0.6)	67.5 (1.4)	87.9 (3.9)	114.9 (2.9)			
Timber	41.9 (0.7)	65.5 (1.4)	86.2 (4.5)	105.1 (4.7)			
Wind	38.0 (2.1)	58.9 (4.4)	78.6 (9.2)	105.2 (21.1)	146.4 (146.4)		
Lower							
Madison	44.5 (1.1)	71.6 (2.5)	93.5 (3.4)	112.6 (2.1)	134.0 (134.0)		
Sevenmile	38.5 (2.8)	61.2 (6.6)	82.3 (12.3)	115.0 (115.0)			
Threemile	40.6 (1.2)	60.7 (3.0)	84.8 (5.8)	112.6 (6.4)	134.0 (6.3)		
Wildcat	43.6 (0.4)	67.8 (0.3)	89.2 (1.0)	107.9 (2.8)	132.7 (11.6)		
Wind	41.6 (1.5)	65.6 (2.6)	88.4 (3.9)	108.9 (1.9)	136.9 (136.9)		

[a] No species targeted for age and growth analysis were sampled

[b] Only one sub-sampled was sampled.

Appendix H. **Proportion of age classes** (%) of central stonerollers, creek chubs, red shiners, and green sunfish from streams sampled on Fort Riley Military Reservation during June and July 1997, 1998. Number in parenthesis represents standard error.

	Percent by age for central stonerollers			
Reach–stream	0	1	2	3
Headwater				
Dry[a]				
Farnum		100 ([b])		
Forsyth	70.8 (29.2)	29.3 (29.3)		
Fourmile	25.7 (7.6)	69.1 (12.9)	5.3 (5.3)	
Little Arkansas	55.6 ([b])	22.2 ([b])	22.2 ([b])	
Rush	4.2 (4.1)	77.1 (22.9)	18.8 (18.8)	
Threemile	22.5 (22.5)	60.0 (10.0)	17.5 (7.5)	
Wind	50.0 (50.0)	50.0 (50.0)		
Mid				
Farnum	23.4 (23.4)	61.6 (38.4)	15.0 (15.0)	
Forsyth	68.8 (0.2)	28.7 (2.5)	2.5 (2.5)	
Honey	96.7 ([b])	3.3 ([b])		
Little Arkansas	46.8 (25.9)	53.2 (25.0)		
Timber	16.1 (11.8)	13.0 (11.2)	11.2 (1.6)	0.7 (0.7)
Wind		95.3 (95.3)	4.7 (4.7)	
Lower				
Madison	38.4 (23.1)	48.9 (19.6))	12.6 (9.3)	
Sevenmile	45.3 (21.7)	52.2 (20.6)	2.6 (2.6)	
Threemile	46.1 (26.5)	51.0 (23.5)	2.9 (2.9)	
Wildcat	23.1 (8.6)	64.6 (7.1)	12.3 (6.4)	
Wind	47.5 (20.3)	44.9 (21.8)	4.5 (4.5)	3.1 (3.1)

Appendix H. Continued (see page 112 for heading).

	Percent by age for creek chubs					Percent by age for red shiners		
Reach–stream	0	1	2	3	4	0	1	2
Headwater								
Dry[a]								
Farnum	100 (100)							
Forsyth	59.7 (37.7)	32.3 (29.7)	8.0 (8.0)				36.7 (1.9)	52.8 (4.4)
Fourmile	8.0 (2.0)	70.3 (4.3)	20.7 (5.3)	1.0 (1.0)			0.1 (0.1)	99.9 (99.9)
Little Arkansas	95.3 ([b])	4.7 ([b])						
Rush	44.3 (44.3)	50.9 (49.1)	4.7 (4.7)	1.0 (0)	0.1 (0.1)			
Threemile	25.0 (25.0)	50.0 (50.0)	25.0 (25.0)					
Wind	45.4 (45.4)	37.8 (28.8)	16.7 (16.6)	0.1 (0.1)		37.7 (22.3)	53.4 (23.4)	8.9 (8.9)
Mid								
Farnum	87.4 (87.5)	12.4 (12.5)	0.1 (0.1)	0.1 (0.1)			100 (100)	
Forsyth	8.9 (4.6)	64.2 (14.2)	26.9 (18.9)					
Honey	28.6 ([b])	57.1 ([b])	14.3 ([b])					
Little Arkansas	36.0 (17.8)	54.9 (8.7)	9.1 (9.1)			21.4 (4.7)	74.5 (0.5)	4.1 (4.1)
Timber	4.3 (3.1)	44.7 (9.8)	41.2 (13.1)	8.5 (5.9)	1.4 (1.4)	21.6 (12.5)	58.2 (7.3)	20.2 (11.1)
Wind	80.9 (80.9)	19.0 (19.0)	0.1 (0.1)				100 (100)	
Lower								
Madison	71.3 (6.4)	26.0 (7.4)	2.6 (2.0)	0.1 (0.1)		46.2 (8.6)	50.8 (9.2)	3.0 (2.4)
Sevenmile	24.8 (9.4)	52.0 (7.2)	18.3 (3.4)	4.9 (2.8)		33.2 (11.3)	62.9 (10.2)	3.9 (2.4)
Threemile	46.5 (19.6)	40.3 (14.1)	9.7 (3.5)	2.5 (2.5)	0.8 (0.8)	28.2 (15.7)	64.6 (12.8)	7.2 (7.2)
Wildcat	6.7 (6.7)	77.3 (8.6)	13.3 (4.2)	2.7 (2.7)		26.8 (5.9)	70.8 (5.7)	2.4 (1.2)
Wind	31.9 (9.9)	49.1 (0.9)	18.9 (10.6)				100 (100)	

Appendix H. Continued (see page 112 for heading).

	Green sunfish							
Reach–stream	0	1	2	3	4	5	6	7
Headwater								
Dry[a]								
Farnum				100 (100)				
Forsyth		79.2 (20.8)	16.7 (16.7)	0.1 (0.1)				
Fourmile								
Little Arkansas		40.0 ([b])	40.0 ([b])	20.0 ([b])				
Rush			20.0 (20.0)	80.0 (80.0)				
Threemile		21.8 (1.8)	40.3 (20.2)	29.3 (24.1)	8.7 (2.0)			
Wind	4.2 (4.2)	49.8 (33.6)	21.0 (16.8)	12.9 (8.7)	8.1 (8.1)	2.7 (2.7)	1.4 (1.4)	
Mid								
Farnum		36.1 (20.3)	36.6 (12.4)	13.1 (6.6)	10.3 (5.5)	3.9 (3.9)		
Forsyth		57.7 (42.3)	15.4 (42.3)	15.4 (15.4)	3.8 (3.8)	7.6 (7.6)	11.5 (11.5)	0.1 (0.1)
Honey		99.8 ([b])	0.2 ([b])					
Little Arkansas		20.6 (4.5)	36.9 (4.8)	26.5 (5.7)	16.0 (3.5)			
Timber	3.1 (2.0)	13.1 (7.8)	32.5 (16.1)	47.1 (18.3)	4.2 (2.4)			
Wind		18.6 (14.8)	35.3 (18.6)	32.0 (1.3)	8.3 (8.3)	0.1 (0.1)		
Lower								
Madison		25.0 (25.0)	41.7 (8.3)	8.2 (8.2)	25.0 (25.0)	0.1 (0.1)		
Sevenmile		41.7 (30.0)	16.7 (16.7)	33.3 (16.6)	8.3 (8.3)			
Threemile	3.0 (3.0)	19.0 (11.2)	37.5 (14.5)	23.8 (6.6)	11.6 (5.8)	5.0 (2.7)		
Wildcat	0.5 (0.5)	19.5 (12.9)	26.1 (4.5)	29.9 (10.8)	5.8 (3.2)	3.2 (2.2)		
Wind	8.1 (4.8)	61.5 (23.8)	10.2 (10.2)	7.7 (7.7)	6.9 (5.5)	5.5 (5.5)		

[a] No species targeted for age and growth analysis were sampled.
[b] Only one sub-sample was sampled.